By this Large margent did the poet mea
To have a comment wrote upon his scene
is it that the Ladys who nere look
In any but a Poem or play Book
Should have great space to scribble down
When such a Lord or fashion comes to town
Like shepherds who in almanak do keep
their sheep
When there cow calvd or when they bought
Is this the case it is meet them
the pen
That that which scap'd the poets should see
Ner did I see
So little in so much as if the rea
of Poetry like lawn were sold by the shee
If this the fashion do continue half a yea
Poets like clerks will make our paper dea

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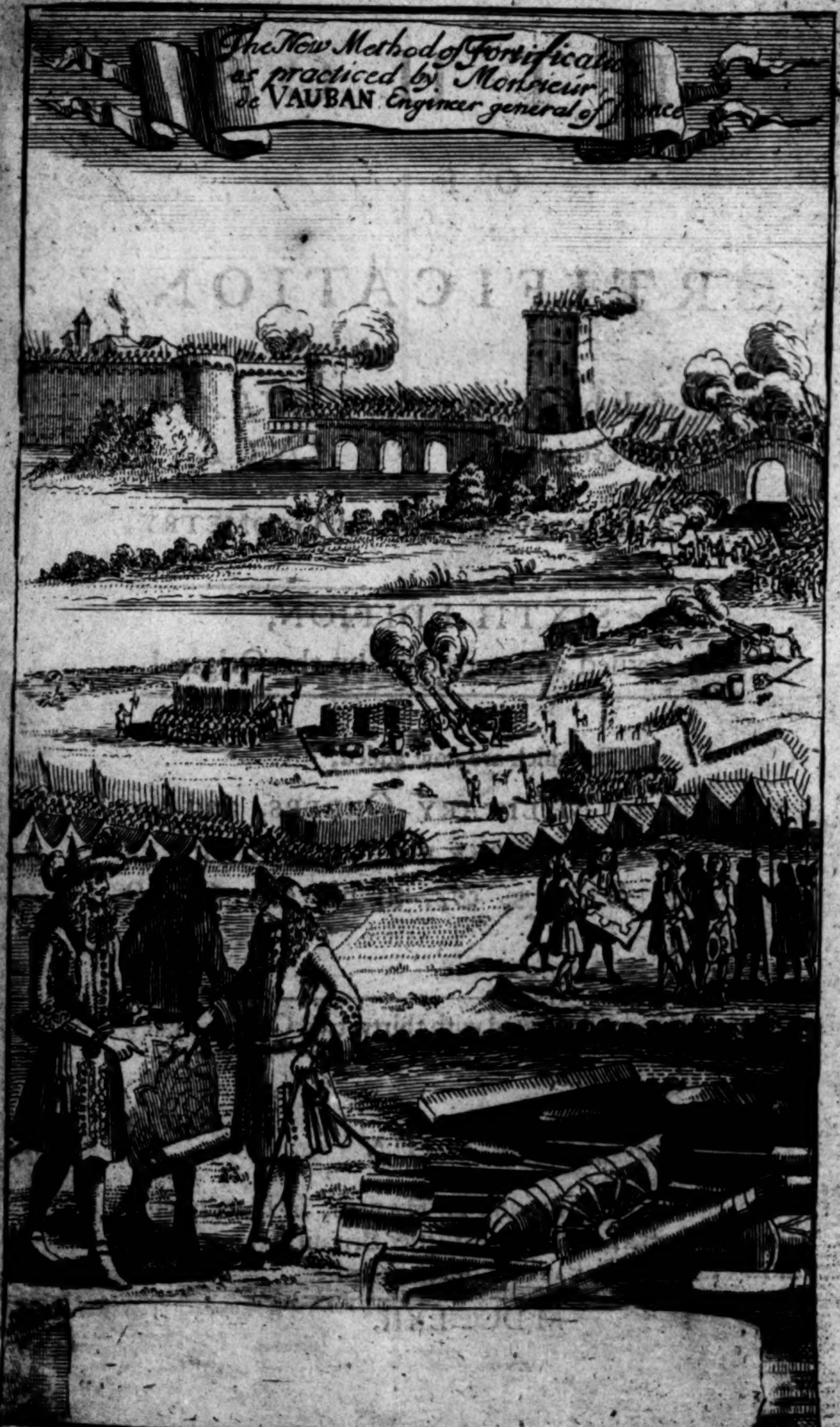
The New Method of Fortificatio
as practiced by Monsieur
de VAUBAN Engineer general of France

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THE NEW METHOD

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FORTIFICATION,

Connolly R.E. 1. April 1861.

Le Prestre

As practiſed by Monſieur *de VAUBAN*,
Engineer-General of *FRANCE*.

Together with a new Treatiſe of GEOMETRY.

The SIXTH EDITION,
Carefully reviſed and corrected by the Original.

To which are now added,
A Treatiſe of MILITARY ORDERS, and the
ART OF GUNNERY, or throwing of
BOMBS, BALLS, *&c.* to hit any Object
aſſigned.

~~33~~

The whole Work illuſtrated with thirty-two Copper Plates.

LONDON:

Printed for C. HITCH and L. HAWES, in Pater-noſter-Row; E. BALLARD, in Little Britain; and J. RIVINGTON, in St Paul's Church-Yard.

M.DCC.LXII.

3

TO HIS
GRACE
THE
DUKE of *ORMONDE*.

May it pleaſe your GRACE,

THE general Complaint of the want of Books of *Fortification* in our *Engliſh* Tongue, has encouraged me to tranſlate that of Monſieur *Vauban*: To which I was invited by the almoſt univerſal Applauſe it has received from the moſt competent Judges. Nothing could have emboldened me to the Preſumption of this Addreſs, but the Good and Welfare of my native Country, by propoſing your Grace to the Imitation of our Nobility and Gentry, which ſeems to be the only Means for this Kingdom to recover its ancient

Glory. I doubt not, but that brave Example which your Grace continually ſets to the whole Nation, will inſpire the Men of Quality to come up to it as near as poſſible : Which, if they had always done, *Vauban* might, without any great Detriment to us, have been confined to the Territories of his Maſter. That your Grace may ever proſper, and receive the Honours due to ſo great Merits; as it is the greateſt Good can be wiſhed you, ſo it is no leſs the unfeigned Deſire of,

May it pleaſe your GRACE,

Your GRACE'*s moſt obedient,*

and moſt humble Servant,

A. S.

THE

THE

PREFACE.

THIS little Tract, which was chiefly deſigned by the ingenious Author for the Uſe and Benefit of young Gentlemen and others, addicted to the Study of this Part of the *Mathematicks*, who have not Leiſure or Opportunity to read over the vaſt Syſtems of voluminous Writers, has deſervedly obtained ſo great a Repute among the Curious, that it is tranſlated into ſeveral Languages; and the Acceptance it has met with, has already ſold off five Impreſſions in our own. It contains an exact and ſufficient Explication of all the Terms that are neceſſary to the Subject; and, in general, all that is requiſite for the Theory and Practice of a good *Soldier*, down from a General to a private Centinel. You have therein exhibited the true Menſuration of *Heights*, *Lengths*, *Planes*, *Solids*, and *Concaves*; as alſo the Science called *The Tranſmutation of Bodies*; which is the Subject of the Firſt Part. In the Second are explained the Rules that are obſerved by the *French* Engineers at this Day, in raiſing their Works; and, at the ſame Time, are produced the different Sentiments of the *French* among themſelves, as to this Matter; it is likewiſe ſhewn wherein their Manner of Operation differs from that of the *Germans*, and other Nations.

Laſtly, The moſt clear and accurate Method of *Fortification* is plainly taught.

The Word *Geometry* is derived from the *Greek*, γῆ and μετρεῖν; importing, *to meaſure the Earth*; ſo that *Geometry* (with reſpect to its Etymology) is only the Art of meaſuring Land; yet in a larger, and more proper Senſe, it is applied to all Sorts of Dimenſions. As for the Original of this Science, it is indeed very uncertain; and it is believed by many, that the *Ægyptians* were the Inventers thereof: For in regard that the River *Nile* does every Year overflow the Country of *Ægypt*; thoſe Inundations which generally overthrew, and confounded all the Land-Marks, obliged the Inhabitants to invent certain Meaſures, by the Means whereof, they might be able to diſtinguiſh, and adjuſt the Limits of their reſpective Grounds from thoſe of their Neighbours, when the Waters were withdrawn. And this Opinion is not altogether to be rejected: Eſpecially if we conſider that *Moſes* is generally reputed to have learned this Art, among others of them, during his Reſidence in the *Ægyptian* Court. However, ſince there were not very many Men who applied themſelves to the Study of good Literature in thoſe early Ages of the World; the *Mathematicks*, and *Geometry* in particular, were, as it were, locked up within the Breaſts of ſome few learned and ſkilful Artiſts, until the Time of *Thales*, who firſt publickly profeſſed them in *Greece*; nevertheleſs the *Grecians* were not very diligent in promoting and improving theſe noble Sciences, and only taught them privately; neither was there any one that undertook to ſhew the Uſefulneſs and Neceſſity of this kind of Learning, until *Euclid* wrote his Elements; which gave Occaſion to the publiſhing of a great Number of excellent Treatiſes on the Subject, that are now extant.

To this Treatiſe you have annexed another of *military Orders*, and the *Art of Gunnery*. So that taking the Whole together, I am apt to think, there will be ſcarce found a Book ſo univerſal of the Kind, and ſo neceſſary in the firſt Place to all military Perſons, of what Order or Rank ſoever; and in the next, to all Gentlemen that are willing to underſtand what they may meet with, not only in reading of modern Hiſtories, but very probably in moſt of the Gazettes of the approaching Summer. However we are willing to ſubmit the Whole to the impartial Cenſure of the candid Reader.

An Advertiſement to the *Book-Binder*.

1. CARE muſt be taken not to cut the blank Paper on which the Plates are wrought off; by reaſon that the Figures muſt be ſo placed as to fold out of the Book.

2. There are eight Figures which muſt be placed at the End of the Treatiſe of *Geometry*, and are marked thus: *Geom. Pl.* 1, 2, 3, 4, 5, 6, 7, 8.

3. The other Figures belong to the *Fortification*, and *Gunnery*, and are to be placed at the End of the Book, and ſet in order as they are marked: A, B, C, D, E, F, G, H, I, K, L, M, N, O, P, Q, R, S, T, V, W, X, Y.

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A NEW TREATISE OF GEOMETRY.

BOOK I.

CHAP. I.

AS an Introduction to our Subject, at our firſt Entry, we ſhall begin with the Definition of *Geometry*, and the Explication of thoſe Terms that are hereafter to be made uſe of.

Geometry is a Science which treats of *Magnitudes*, and it is the principal Part of the Mathematicks.

1. *Magnitude* is a continued Quantity, which conſiſts either in *Lines* or *Angles*, in *Surfaces* or *Bodies*.

2. A *Linc* is a Length without Breadth, whoſe Extremities are called *Points*.

3. A *Point* is ſomething which cannot be divided.

4. A *Line* is right, crooked, or mixed: A right Line is that which goes without Turnings from one Point to another. A crooked Line is that which goes off from a right Line, by one or more Turnings: And a mixed Line is that which is Part right and Part crooked.

5. A *Surface* is Length with Breadth; whoſe Bounds are called *Lines.*

6. Theſe Lines are either parallel or oblique. Parallel Lines are thoſe which are every where equally diſtant from each other. Oblique Lines are thoſe which meeting at a Point make an Angle.

7. It is called a right Angle when one of the Lines is perpendicular to the other. It is called an oblique Angle when one of the Lines is not perpendicular to the other. It is called a right-lined Angle when it is made up of two right Lines. It is called a Curve-lined Angle when it is made up of two crooked Lines. It is called a mixed Angle when one of the Lines is right, and the other curve. It is called an acute Angle when it is leſs than a right one. And it is called an obtuſe Angle when it is greater than a right Angle.

8. A *Figure* is a Magnitude bounded by one or more Lines and Surfaces, whereof ſome are plain, ſome ſolid.

9. A *Circle* is a plain Figure bounded by a Circumference, the middle Point whereof is called the Center, from which all right Lines drawn to the Circumference are equal.

10. A *Diameter* is a right Line, which goes through the Center, and touches the Circumference in two Points.

11. A *Semi-Circle* is the half of an Entire Circle.

12. An *Oval* is a plain Figure bounded by its own Circumference, within which no Point can be taken from which all right Lines drawn to the Circumference can be equal.

13. A *Triangle* may be conſidered either with reſpect to its Sides, or its Angles. In reſpect to its Sides, it is either an Equilateral, which has three equal Sides: Or an Iſoſceles, which has two Sides only equal: whoſe third is called the Baſe: Or a Scalene, which has three unequal Sides: In reſpect of its Angles, it is either right-angled, which has one right Angle: Or acute-angled, which has three acute Angles: Or obtuſe-angled, which has one obtuſe and two acute Angles. One of the Lines in a right-angled Triangle is called the Baſe: The ſecond the Perpendicular: And the third the Hypothenuſal.

14. A *Quadrilateral* Figure is that which has four Sides and four Angles: And it is either Equilateral, which has four equal Sides, or Inequilateral, whoſe Sides are unequal.

15. An *Equilateral* Quadrilateral Figure has either right Angles as a Square, or oblique Angles as a Rhombus.

16. An *Inequilateral* Quadrilateral Figure is either a Rect-angle or Right-angled Parallelogram, which has its oppoſite Sides parallel and conſequently equal, and its Angles right, or a Rhomboides which has its oppoſite Sides equal and parallel; all other Quadrilateral Figures are called *Trapeziums.*

17. A *Tetraëdron* is a ſolid Figure, or a Body which is bounded by four equal Triangles.

18. A *Pyramid* is a Body bounded by ſeveral Triangles, which making one Surface for a Baſe, meet all in one Point.

19. A *Priſm* is a Body which has two Baſes, equal and parallel to each other.

20. A *Parallelepiped* is a Body bounded by ſix Parallelograms, whereof the two oppoſite ones are always equal and parallel,

21. A ſolid *Trapezium*, or Trapezoidal ſolid is a Body bounded by plain Surfaces, which form neither a Priſm, nor a Parallelepiped.

22. A *Cone* is a Body made by the turning of a right-angled Triangle round a Circle, the angular Point of the right Angle being fixed in the Center.

23. A *Cylinder* is a Body made by the turning of a right-angled Parellelogram round one of its Sides, till it end where it began.

24. A *Cube* is a Body bounded by ſix equal Squares.

25. An *Octaëdron* is a Body bounded by eight equal and equilateral Triangles.

26. A *Dodecaëdron* is a Body bounded by twelve equal and equilateral Pentagons.

27. An *Icoſaëdron* is a Body bounded by twenty equal and equilateral Triangles.

28. A *Triangular Priſm* is a Body bounded by three right-angled Parallelograms, having two Triangles for its Baſes.

29. A ſolid *Rhomb* is a Body bounded by ſix equilateral oblique-angled Squares.

30. A ſolid *Rhomboid* is a Body bounded by four oblique-angled Parallelograms, having two oblique-angled equilateral Squares for their Baſes.

CHAP. II.

To know how Figures are made, the following Problems muſt be examined.

PROBLEMS.

I. *To draw a Line parallel to give a Line.*

MARK upon the given Line any two Points A B where you pleaſe, and from them as Centers at an equal Diſtance draw two Arches E F, in drawing a right Line by E F you have your Parallel.

II. *From the Point G, to draw a Parallel to a given Line H I.*

1. Draw an Arch from the Point G, which touches the given Line only in K.
2. With the Diſtance G K, draw another Arch upon the given Line MN..
3. The Line drawn by G N ſhall be parallel to the given Line H I.

III. *To raiſe a Perpendicular on a given Line, from a given Point.*

1. Take a Diſtance from the given Point (what pou pleaſe) to the right, as A B.
2. Take the ſame Diſtance to the left, as A C.
3. Take B C and draw two Arches which interſect each other at D.

4. Join D and A together, and you will have your Perpendicular.

IV. *To raiſe a Perpendicular at the End of a given Line AB.*

1. Draw a Circle to the Point B, from the Center C, which may be taken at Pleaſure.

2. From the Point D, where the Circle cuts the given Line, draw a right Line through the Center C, till it touches the Circle on the other Side, as at E.

3. Join E and B together, and you will have your Perpendicular.

V. *From a given Point G, to let fall a Perpendicular upon a given Line.*

1. Draw an Arch from the Point G, which may cut the given Line in two Places, as CD.

2. From CD draw two Arches under the Line which ſhall interſect each other at E.

3. Join E and G together, and you will have your Perpendicular GF.

VI. *To divide a given Line into two equal Parts.*

1. From the Points AB draw two Arches which ſhall interſect above the given Line at C, and below it at D.

2. Join C and D together, and you ſhall have your Line cut into two equal Parts.

VII. *To divide a Line A B into ſeveral equal Parts.*

1. Draw CD a Line at Pleaſure, and mark as many Parts as the given Line A B ought to have; ſix for Example, upon this Line as C E.
2. Take C E and draw two Arches which may interſect in F.
3. Draw all theſe ſix Parts in F.
4. Take the given Line A B, and lay it upon the Lines F E and F C, as G H.
5. Join GH together, you will have your given Line AB divided into ſix equal Parts.

VIII. *To deſcribe an Angle equal to an Angle given.*

1. Let the given Angle be B A C.
2. Draw the Arch A D E.
3. Draw a Line I L, and upon this Line an Arch with the Diſtance A D, as F G.
4. Set the Diſtance D E upon the Arch F G, as F H.
5. Draw a right Line from the Point I to the Point H, which will make an Angle equal to the given Angle.

IX. *To divide an Angle into two equal Parts.*

1. Let the given Angle be B A C, draw the Arch A D E.
2. From the Points D E draw two Arches which ſhall interſect each other at F.
3. The Line drawn from F to A will cut the Angle into two equal Parts.

X. *To draw a Circle through three given Points ABC, or to find the Center of a given Circle, or to finiſh a Circle when there is but one Part given.*

1. With the Points A B, make two Arches which ſhall interſect at D above, and at E below the given Points.

2. Draw a right Line from the Point D to G.

3. Do the ſame Thing with B C, ſo that they may interſect in F G.

4. Draw another right Line from F to G, and there where this Line interſects the firſt, as for inſtance at G, you will find the Center, by which you may draw the Circle through the three given Points.

XI. *To make a Circle two, three, or four Times bigger than the given one, &c.*

1. Divide the given Circle into four equal Parts A B C D, with the Center marked at E.

2. Take the Diſtance A B and put it from E upon the Perpendicular, as E F, and with this Diſtance draw a Circle as big again as that given.

3. To make a Circle twice as big, take A F, and put it from E upon the firſt Perpendicular, as E G, and the Diſtance E G will be the Semi-diameter of the demanded Circle.

4. To make a Circle thrice as big, put the Diſtance A G upon the ſame Perpendicular, as E H, and the Diſtance E H will be the Semi-diameter of the demanded Circle. Thus you may enlarge a Circle for ever.

XII. *To make an Oval.*

1. Draw a Line, and thereupon the Circle B A C.

2. From C draw another Circle through B, as C B D.

3. Take Care that theſe two Circles interſect each other, as in E F.

4. From the Point of Interſection E, draw right Lines through B C, which ſhall cut the two Circles in G H.

5. From the Point E, draw an Arch from G to the Point H.

6. Keep this Diſtance, and do the ſame Thing from the other Point of Interſection F, as I K, and ſo your Oval will be compleat.

XIII. *To draw a Spiral Line.*

1. Upon a ſtraight Line, draw the Arch A B C.

2. Take B C, and fixing one Point of the Compaſs upon B, draw from the Point C another Arch, which ſhall touch the ſame Line in D.

3. Take the firſt Center A, and draw another Arch from D, that ſhall cut the Line in E.

4. Return to the Point B, and from it as a Center draw from E another Arch to F.

5. Take A as a Center, and draw an Arch from F to G; and ſo on for ever.

XIV. *To divide a Circle into 360 equal Parts.*

1. Divide a Circle into four equal Parts, as A B C D, whoſe Center is E.

2. From A through E draw the Arch F G; ſo alſo draw from B the Arch I H, and from C draw the third K L; and at laſt from D draw the laſt Arch M N.

3. Having by theſe Articles divided the Circle into twelve equal Parts, afterwards divide every one of theſe twelve into three other equal Parts, and then you will have thirty-ſix equal Parts.

4. Divide afterwards every one of theſe thirty-ſix into ten equal Parts, and your Circle will be divided into three hundred and ſixty equal Parts.

XV. *To make an Equilateral Triangle.*

Take a given Line A B, and from thoſe two Points draw two Arches which ſhall interſect at C; from C draw two right Lines to A and B; theſe will make an Equilateral Triangle.

XVI. *To make a Triangle equal to a given one.*

1. Let the given Triangle be A B C, draw a Line at Pleaſure, and mark thereupon the Length A B, as D E.

2. Take the Diſtance B C, and from the Point E draw an Arch.

3. Take the Diſtance A C, and from D draw another Arch which ſhall interſect the firſt at F.

4. Join A E and F D together, you will have a Triangle equal to the given one A B C.

XVII. *To divide a Triangle into ſeveral equal Parts.*

1. Let A B C be the Triangle to be divided into five other Triangles: Firſt divide the longeſt

Side B C into five equal Parts, ſo that the fifth Part, marked at D, may be joined to A.

2. Divide the longeſt of the two other Sides into four equal Parts, and let one of them marked G be joined to D.

3. Divide the remaining Part D C into three equal Parts, and join that marked F by a right Line to G.

4. Divide the Remainder G C into two equal Parts, and join that marked E by a right Line with F. So you may have five equal Triangles, *viz.* ABD, ADG, GDF, GFE, and EFC.

XVIII. *To make a Square.*

1. Take the Line A B, and raiſe a Perpendicular upon B, of the ſame Height as B C.

2. With the ſame Diſtance make two Arches from A and C which ſhall interſect at D.

3. Join DA, and DC by right Lines: And you will have a Square.

XIX. *To make a Parellelogram.*

1. Draw a long Line A B, and upon B raiſe a ſmall Perpendicular B C.

2. Take the Diſtance BC, and by the Point A draw an Arch.

3. Once more take the Line A B, and by the Point C make an Arch which ſhall interſect the other at E; join E to A and C, and you will have this Parallelogram.

XX. *To draw a Pentagon of equal Angles without a Circle.*

1. Draw a long Line A B, and mark upon it the Diſtance A C.

2. Raiſe a Perpendicular upon C, equal to A C, as C D.

3. Divide the Line A C into two equal Parts, as A E, E C.

4. Set the Point of the Compaſs upon E; and with the other Point draw an Arch from D, which ſhall touch the given Line at F.

5. By the Points A C, and the Diſtance A F, draw two Arches interſecting at G.

6. Take only the Diſtance A C, and by the Points G A, draw two Arches interſecting each other in I: So likewiſe by the Points G C, draw two other Arches which ſhall interſect each other in K.

7. Join A I, I G, G K, and K C together by right Lines, and you have your Pentagon.

XXI. *To make a right-lined Triangle equal to a Circle given.*

1. Divide the Diameter of A B the given Circle into ſeven equal Parts.

2. Raiſe a Perpendicular upon B three Times as long as the Diameter A B, and a ſeventh Part over, as B C.

3. Draw a right Line from C to D the Center of the given Circle, and that gives you the Triangle.

XXII. *To find the Circumference of a Circle, having only the Diameter.*

This Problem muſt be wrought after the ſame Manner as the foregoing one.

XXIII. *To make a Square equal to a given Circle.*

1. Divide the Diameter A B into ſeven equal Parts.
2. Double this Diameter, and add a ſeventh Part of itſelf to it, as A C.
3. Divide the firſt Diameter A B into two equal Parts, as A D.
4. Divide the Line DC into two equal Parts, and taking the middle Point E, draw from D to C an Arch, as D F C.
5. Raiſe a Perpendicular upon E to touch the Circle in F: This Line E F ſhall be a Side of the required Square: The reſt is wrought by the eighteenth Problem.

XXIV. *To make one Square equal to two.*

1. Let one of the given Squares be A B C D, and the other E F G H.
2. Join them both ſo, that the Sides BC, F E, may make one right Line C B E.
3. Join A to E, and raiſe a Perpendicular upon E of the ſame Length, as A E.
4. Keep the ſame Length, and from the Points, K A, make two Arches to interſect in I.
5. Join K I, and I A, and your Square will be made.

XXV. *To make a Square equal to a Parallelogram.*

Let the given Parallelogram be A B C D.

1. Lengthen the Baſe D C, and add to it the other Side of the Parallelogram B C, as C E.

2. Divide the Diſtance D E into two equal Parts, and from the middle Point F draw a Semicircle, from D towards E.

3. Raiſe a Perpendicular upon C to touch the Semi-circle in G; this will be a Side of the required Square; ſet it upon the firſt lengthened Line, and you will have another Side, as C I.

4. Keep the ſame Diſtance, and from the Points G I, make two Arches to interſect in H; join GH, and HI together, and your Square will be made.

XXVI. *To make a Square two, three, or four Times greater than it is.*

Let the given Square be A B C D.

1. Lengthen the Side A B, and take the Diſtance B D, and ſet it upon the lengthened Side A B, as A E, and it will be a Side of a Square double to that given at firſt.

2. Afterwards obſerve what was ſaid above in the eleventh Problem.

XXVII. *To make an Equilateral right-angled Square equal to an oblique-angled Parallelogram ABCD.*

1. From the Points A B let fall Perpendiculars to the lower Line, as A E, and join it afterwards to the Perpendicular B, as B F.

2. And when you have the right-angled Parallelogram AEBF, work on by the twenty-fifth Problem.

XXVIII. *To make a right-angled Square equal to the Rhomb ABCD.*

1. From the Points BC, let fall Perpendiculars upon the Line, and ſet the Diſtance BE, upon the other Point C, as CF.

2. Join EF together, and the Sides BCEF will make a right-angled Square equal to a given Rhomb.

XXIX. *To make an Equilateral right-angled Square equal to the Triangle ABC.*

1. Lengthen the Baſe CB, and divide the ſame Baſe into two equal Parts, as CD, DB.

2. From the Point B let fall a Perpendicular equal to BD, as BF.

3. Lengthen BF upwards, and from the Point A draw a Parallel to the Baſe CB, which ſhall cut the lengthened Line BF in E.

4. Divide the Diſtance FE into two equal Parts, and from G the middle Point draw an Arch from E to F; and from the Point H, where this Arch touches the firſt lengthened Line CB, to B ſhall be the firſt Side of the Square, which laid upon the Line BE, will give another Side BI; afterwards from the Points IH, make two Arches which ſhall interſect each other in K; and join HK and KI together, and your Square will be made.

XXX. *To make a Parellelogram equal to a given Triangle ABC.*

1. Divide the Baſe A B into two equal Parts, as A D, D B.

2. Divide the Side C B into two equal Parts, as B E, E C.

3. Draw a right Line from D to E, what Length you pleaſe, and take the Diſtance D E, and ſet it from the Point E, to lengthen it, as E F.

4. Take D F, and from the Point B make an Arch.

5. Take D B, and from F interſect this Arch in G.

6. Join F G and G B together, and your Parallelogram will be made.

XXXI. *To make a Parallelogram equal to a right-angled Square ABCD.*

1. Lengthen the Side of the Square A B, adding double its own Length to it, as B F.

2. Divide the Side of the Square B C into two equal Parts, as B E, E C.

3. Take B F, and from the Point E make an Arch.

4. Take B E, and interſect this Arch from the Point F in G.

5. Afterwards join E G and F G together, and you have the Parallelogram required.

XXXII. *To*

XXXII. *To make a right-lined Figure equal to a Figure given.*

Let the given Figure be ABCDE.

1. Take any one of the Points, which you pleaſe; A for inſtance.

2. From A make as many Triangles as there are oppoſite Angles in the Figures ABC, ACD, ADE.

3. Then take a Line at Pleaſure of the Length of AB, as FG.

4. From the Point G, with the Diſtance BC, make an Arch.

5. With the Diſtance AC interſect this Arch from F in H, and join GH together.

6. From the Point H, with the Diſtance CD make another Arch, and interſect it from F in I, with the Diſtance AD, and this muſt be joined to H.

7. Take AE, and from this Point F make the laſt Arch; interſect it from I in K, with the Diſtance DE, and join it with IF: So the Figure FGHIK, will be equal to the given Figure.

CHAP. III.

Of BODIES.

PROBLEMS.

I. *To make an equilateral Tetraëdron.*

1. MAKE an equilateral Triangle ABC.

2. Place another equilateral Triangle

upon every Side, as ABE, BCD, and ACF, and your *Tetraëdron* is made.

II. *To make a Cube.*

1. Make an equilateral right-angled Square ABCD.

2. Upon every Side place another Square equal to the firſt, as ABEF, BCGH, DCIK, ADLM.

3. Join EF, GH, IK, and LM together by right Lines.

4. Place another Square equal to the reſt upon one of theſe four, as KINO, and the *Cube* will be made.

III. *To make a Parallelepiped.*

1. Make a Parallelogram ABCD, and lengthen the Sides AC, BD, above and below.

2. Mark any Diſtance above AB you pleaſe; as AE, BF; and mark the ſame under CD as CG, DH, then join EF and GH together.

3. Above EF, mark the Diſtance AC, or BD, as I and K: and join IK together.

4. Lengthen EF and AB; upon the lengthened Lines mark the Diſtance AC, or BD, as FL, BM, EN, and AO.

5. Join L and MN, and O, together, and your *Parallelepiped* will be made.

IV. *To make a Cylinder.*

1. Make a long Square ABCD.

2. Divide AB into twenty-two equal Parts.

3. Upon what Point you pleaſe raiſe a Perpendicular of the Lengh of ſeven of theſe twenty-two Parts, as F G.

4. Upon the Line D C mark the Diſtance F B, as D H.

5. Let fall a Perpendicular from H of the Length of F G, as H I.

6. Divide F G and H I into two equal Parts: And from their middle Points draw Circles, and the *Cylinder* will be made.

V. *To make a Cone.*

1. From the Point A taken at Pleaſure draw an Arch.

2. Divide it into twenty-two equal Parts and join the Extremities G H, with A.

3. Let fall a Perpendicular where you pleaſe from the Arch, equal to ſeven of thoſe Parts, as B C.

4. Divide B C into two equal Parts: From its middle Point, draw a Circle, which ſhall be a Baſe of a *Cone* made upon the Arch G H.

VI. *To make a Triangular Priſm.*

1. Make a right-angled Parallelogram A B C D.

2. Divide A B and C D into three equal Parts, as A E, E F, F B, and C G, G H, H D.

3. Join E G and F H together by right Lines

4. From E and F make two Arches to interſect in I, and join I E, and I F together.

5. Upon G H make an equilateral Triangle K, and your *Priſm* will be made.

VII. *To make an Octaëdron.*

1. Upon one Line make three equilateral Triangles, as A B C, B D E, and E F G.

2. Lengthen the Line C G; and mark upon the lengthened Line the Diſtance E G, as G H.

3. Join H F together, and with the ſame Diſtance from D F, make two Arches to interſect at K, and from C E, two others to interſect at I.

4. Join C I, and I E together, as alſo D K and F K, and the *Octaëdron* will be finiſhed.

VIII. *To make a Dodecaëdron.*

1. Make a regular Pentagon A B C D E: The Center whereof may be F.

2. Take the Diſtance A F, and therewith from every Side draw two Arches mutually interſecting, as A B G, B C H, C D I, D E K and E A L.

3. From the Points G H I K L, with the Diſtance A B, deſcribe five Circles, and divide each of them into five equal Parts; and you will have five other equal Pentagons about your firſt.

4. With the Diſtance H M or H N from M and N draw two Arches to interſect each other in O: From this Point by the ſame Diſtance, draw another Circle through N and M, and divide it as you did the other into five equal Parts, and as M N P Q R, and there join them all together.

5. Take the Diſtance O N, and from P and Q draw two Arches to interſect each other in S, which is a Center, from whence a Circle ſhall be drawn through P Q, which ſhall afterwards be di-

vided into five equal Parts, QP, PW, WU, UT, and TQ.

6. Repeat the ſame Operation upon TQ, TU, UW, and WP, and your *Dodecaëdron* will be finiſhed.

IX. *To make an Icoſaëdron.*

1. Make five equilateral Triangles upon the ſame Line, as ABC, BDE, DFG, FHI, and HKL.

3. From the Points AC make two Arches which ſhall interſect each other in M.

3. Join AM and ML together by right Lines.

4. Upon MC raiſe the equilateral Triangle N; upon CE, O; upon EC, P; upon GI, Q; and laſtly upon IL, R.

5. Repeat the ſame Operation upon their Baſes: For Inſtance, ſet the equilateral Triangle S upon AB; the Triangle T upon BD; the Triangle U upon DF; W upon FH; and at laſt the Triangle X upon HK: Which will finiſh the *Icoſaëdron.*

X. *To make a ſolid-Rhomb.*

1. Upon the ſame Line make four equilateral Triangles, GIM, IKN, KLO, LHP.

2. Join MP together by a right Line: As alſo GM, IN, KN, LO and HP.

3. Add to the Line NI its own Length beyond it, as IQ.

4. Add to the Line OK double its own Length, as KR, RF.

5. Join RI and FQ together.

6. Add to the Line IR its own Length beyond it, as RT: Do the ſame to NK, as KU: Then join UT together, and your ſolid *Rhomb* is made.

XI. *To make a ſolid Rhomboid.*

1. Make an equilateral Triangle ABC, and from BC another D.

2. Add to the Line CD twice its own Length, as DE, EF.

3. Add to DB its own Lenth, as DG.

4. Add to CB thrice its own Length, as BH, HI, IK.

5. With the Diſtance IB from the Point G make an Arch.

6. Make another Arch with the Diſtance BG from I, which ſhall interſect the firſt at L, and join GL and LI by right Lines.

7. Add to GH thrice its own Length; HM, MO, and OP; and join M and I together.

8. From K and M draw two Arches to interſect at N, and join KN, NM, MD, OE, and PF together: And the Rhomboid will be finiſhed.

XII. *To make a Polyëdron whoſe Baſe ſhall be a Pentagon.*

1. Make a Square ABCD: And divide AB and CD into five equal Parts, as CE, EF, FG, GH, HD; as alſo AI, IK, KL, LM, and MB.

2. Join EI, and FK, and GL, and HM, and DB, together.

3. Divide one Part of each of theſe Lines into twenty-two equal Parts: As FG, and KL.

4. Divide one of thoſe twenty-two Parts into three other equal Parts.

5. Take eighteen of theſe twenty-two Parts, and $\frac{2}{3}$ of one more, as FN, and KO; and draw two Arches from KL, as alſo from FG, which ſhall interſect in P and Q: From P and Q as Centers draw two Circles, which being divided into five equal Parts by the Diſtances FG, and KL, your Figure will be compleated.

CHAP. IV.

Of PYRAMIDS.

PROBLEMS.

I. *To make a Triangular Pyramid.*

1. FROM the Point A taken at Pleaſure draw an Arch, which divide into three equal Parts, BC, CD and DE.

2. Join AB, AC, AD, and AE with right Lines; as alſo BC, CD, and DE, with other right Lines.

3. From the Points CD, with the Diſtance CD, draw two Arches to interſect in F.

4. Join CF and DF, and the *Pyramid* will be compleated.

II. *To make a Pyramid with an equilateral Square for its Baſe.*

1. From the Point A draw an Arch: Divide it into four equal Parts, BC, CD, DE, and

E F, which are to be joined together by right Lines, as alſo A B, A F, A C, A D, and A E.

2. From the Point C, let fall a Perpendicular equal to C D, as C G.

3. With the Diſtance C G from G D, draw two Arches to interſect each other in H.

4. Join H G and D H together by right Lines, and you have the required *Pyramid*.

III. *To make a Pyramid whoſe Baſe is a Parallelogram.*

1. From the Point A draw a Circle, in which firſt mark a larger Arch, as B C; then a ſmaller one, as C D, then mark a third Arch (D E) equal to the firſt, and a fourth (E F) equal to the ſecond.

2. Join A B, A C, A D, A E, A F, as alſo B C, C D, D E, E F, by right Lines.

3. From C let fall a Perpendicular equal to C D, as C G.

4. Take the Diſtance C G, and from B draw an Arch.

5. Take the Diſtance B C, and from G draw another Arch to interſect the firſt in H; join B H and H G together, and the Problem is finiſhed.

IV. *To make a Pyramid with an equilateral Pentagon for its Baſe.*

1. Draw an Arch from A, which divide into five equal Parts, B C, C D, D E, E F, F G.

2. Join them all to A, and one to another, B to C, C to D, D to E, E to F, F to G, by right Lines.

3. Divide one of theſe five Parts, as D E, into twenty-two equal Parts, and one of them into three.

4. Take eighteen of the twenty-two Parts, and two of the three little Parts, and from the Points D E make two Arches to interſect each other in H, which is the Center, from whence you are to draw a Circle big enough to be divided into five Parts, equal to the Diſtance D E. When you have this Pentagon for a Baſe, the Work is done.

V. *To make a Pyramid, which ſhall have an Equilateral Hexagon for a Baſe.*

1. Draw an Arch from A, and divide it into ſix equal parts, B C D E F G I.

2. Join them to the Center A, as alſo B to C, C to D, D to E, E to F, F to G, G to I.

3. Take one of theſe ſix Parts (D E) and from D and E make two Arches to interſect in H.

4. From H draw a Circle big enough to be divided into ſix Parts equal to D E.

5. Having this Hexagon as a Baſe for the Pyramid, the Problem is wrought.

VI. *To make a Pyramid with a Heptagon for its Baſe.*

1. From A draw an Arch, and divide into ſeven equal Parts, B C D E F G H.

2. Join them to A, and alſo B to C, C to D, D to E, E to H, H to G, G to F, F to I, by right Lines.

3. Divide one of theſe Parts, F G for Inſtance, into ſeven equal Parts, and then one of theſe ſeven into eight more; then take eight of the larger

Parts, and the half Part of a little one, and with that Diſtance from the Points F G, make two Arches to interſect each other in K; for which as a Center draw a Circle through F G, which muſt be divided into ſeven Parts equal to F G, which when joined together, will ſerve for a Baſe of the Pyramid required.

VII. *To make a Pyramid with an Octagon for its Baſe.*

1. From A draw an Arch, divide it into eight equal Parts, B, C, D, E, H, I, F, G, join theſe Points one to another, and alſo to A by right Lines.

2. Divide one of theſe Parts, as F G, into ſeven equal Parts, and one of theſe ſeven into ſeven others.

3. Take nine of the larger, and one and a half of the ſmaller Parts, and with that Diſtance from F and G, make two Arches to interſect each other in K.

4. From K through F G draw a Circle, divide it into eight Parts equal to F G, and then join them by right Lines: So you will have an Octagon to be a Baſe to the Pyramid required.

VIII. *To make a Pyramid with an Enneagon for its Baſe.*

1. From A draw an Arch, and divide it into nine equal Parts, B C D E F G H I K; join theſe together, and with A by right Lines.

2. Divide any one of theſe Parts, as K M, into ſeven equal Parts, and one of them into ſeven more.

3. Take ten of the former, and two of the latter, and from the Points K M make two Arches to interſect each other in M with the Length of thoſe Parts, as a given Diſtance.

4. From M draw a Circle through K I, which muſt be divided into nine Parts equal to K I; join theſe together by right Lines: So you have the Enneagon which was wanted for a Baſe for the Pyramid required.

IX. *To make a Pyramid with a Decagon for its Baſe.*

1. From A draw an Arch, which divide into ten equal Parts, to be joined to each other, and to A, as B C D E F G H I K L.

2. Divide one of theſe ten Parts into ſeven, and one of theſe ſeven into eight more.

3. Take eleven of the former, and two and a half of the latter, and with that Diſtance from F G, draw two Arches which ſhall interſect each other in O.

4. From O draw a Circle through F G, which divide into ten Parts equal to F G, and there will be a Decagon for a Baſe to the Pyramid.

X. *To make a Pyramid with an Endecagon for its Baſe.*

1. From A draw an Arch, and divide it into eleven equal Parts, to be joined to each other, and all to A, as B C D E F G H I K L M.

2. Divide one of them (F G) into ſeven equal Parts, and one of theſe ſeven into ſeven more.

3. Take twelve of the former, and one and a half of the latter, for a Diſtance, whereby from F G to draw Arches which ſhall interſect each other in N.

4. From N draw a Circle through F G, which may be divided into eleven Parts equal to F G, join them together, and you have the Baſe of the required Pyramid.

XI. *To make a Pyramid with a Dodecagon for its Baſe.*

1. From A draw an Arch, which divide into twelve equal Parts, which are to be joined to A, and each to other by right Lines, as B C D E F G H I K L M N.

2. Divide any one (F G) into ſeven equal Parts, and one of theſe ſeven into ſeven others.

3. Take thirteen of the former, and one and a half of the latter, for a Diſtance whereby from F G to draw two Arches which ſhall interſect each other in O.

4. From O draw a Circle through F G, and divide it into twelve Parts equal to F G, which when joined by right Lines, will give a Baſe of the Pyramid that was required.

⁂

BOOK II.

AS all Rivers have their particular Branches, and every general Science its Diviſions, and its Parts; ſo *Geometry*, generally taken, is the Mother of ſeveral other Arts and Sciences, whereof we ſhall treat in this ſecond Part. Theſe are, Meaſuring of Heights, of Diſtances, of Plains, of Solids, of Concaves, and the turning of one Body into another.

CHAP. I.

Of Meaſuring of Heights.

MEaſuring of Heights is a Science which ſhews how they are to be meaſured: But becauſe there are ſeveral Inſtruments for that Purpoſe, as a Quadrant, a Pantometer, an Aſtrolabe, a *Jacob*'s Staff, *&c.* we ſhall at preſent only make uſe of the Aſtrolabe, becauſe it is the ſureſt and the moſt convenient: And we ſhall know how it is to be uſed by the following Problems.

PROBLEMS.

I. *To take the Vertical Height of any Thing, when you can come to the Bottom.*

Let the Height of a Tower A B be to be meaſured

1. Draw a right Line as you pleaſe from the Point A, as A C.

2. Meaſure the Line A C with your Scale, or your Chain, of 26 Feet for Inſtance.

3. Set the Staff, upon which the Aſtrolabe is horizontally faſtened upon C, ſo that by the fixed Sights, one may ſee the Line C A, from one End to the other, as far as the Tower, and that by the two other movable Sights the Point B, which marks the Height of the Tower, may alſo be ſeen.

4. When the Inſtrument is thus fixed, compute whether the Angle D C E be forty Degrees.

5. Then draw upon a Paper a right Line of the Length of A C, as F G: But this muſt be done by a ſmall Scale made upon the Paper, or by a Scale of Wood or Latten: Afterwards erect a Perpendicular upon G.

6. Take the Index, and ſet it directly upon F G, ſo that the Middle of it may anſwer to the Point F: Then compute an Angle of forty Degrees equal to D C E as F H I.

7. From F draw a right Line through I, till it touches the Perpendicular G in K.

8. With a ſmall Scale meaſure the Height of K G, and add the Height of the Staff to which

the Aſtrolabe is faſtened, and the Sum will give you the Height of the Tower A B.

II. *To meaſure a Vertical Height where you cannot come at the Bottom.*

Let A B be the Height to be meaſured; the foot inacceſſible, becauſe of a River which hinders all approaches.

1. Draw a right Line upon the Ground, on this Side of the River, as C D; let it be twenty-two Feet long: (Take Notice when you can raiſe a right-angled Triangle upon this Line, oppoſite to the Height which you would meaſure, it is much more convenient, otherwiſe the Operation is the ſame.)

2. Set the Inſtrument upon C, ſo that by the immovable Sights you may ſee the Point D directly, and by the two movable ones you may ſee the Point A beyond the River: When this is done, compute the Angle C E F, which may be of ninety Degrees.

3. Set the Inſtrument upon D, ſo that the fixed Sights may make one Line with D C; by the two others you will ſee the Point A: this Angle ought to have twenty-eight Degrees.

4. Draw upon Paper a Line equal to that drawn in the Field (C D) as G H of twenty-two Feet.

5. With the Index take an Angle at H equal to the Angle A C D, *viz.* of ninety Degrees, as I H K, and lengthen the Side H K. Afterwards upon the Point G take another Angle of twenty-eight Degrees, equal to the Field-Angle O D P, as GLM, and then lengthen the Side G M till it

cuts the other HK, in N, and this Point N will mark the Foot of the Height A.

6. Having the Diſtance from the Inſtrument to the Foot of the Tower, it will be an eaſy Thing to work the reſt by the foregoing Problem.

II. *To meaſure a Perpendicular Height, where you can come at the Bottom, with the Shadow of a Staff.*

1. Faſten a Staff a Foot longer perpendicularly into the Ground, as A B, and meaſure the Shade by the Staff, three Feet for Inſtance.

2. With the Shade of the Staff, *viz.* three Feet, meaſure the Shade of the Houſe D E, whoſe Height you would know; and as many Feet as the Shade of the Houſe exceeds the Shade of the Staff, ſo many Feet high will the Houſe be: For Inſtance, if the Shade of the Houſe be twenty-four Times longer than that of the Staff, then we ought to ſay that the Houſe is twenty-four Feet high.

Or thus.

1. Erect a Stick, divided into ten equal Parts, Feet, or Inches, perpendicularly in the Ground, and at the ſame Time meaſure the Shade cauſed by this Staff, twenty Feet for Inſtance.

2. Meaſure alſo the Shadow of the Houſe, whoſe Height you would know, for Inſtance thirty-eight Feet.

3. By the *Rule of Three* ſay, If the Shadow of twenty Feet gives a Height of ten Feet, what will the Shadow of thirty-eight Feet give? *Anſw.* nineteen Feet.

IV. *To*

IV. *To meaſure the Inclination of a Mountain.*

Let the Inclination of the Mountain AB be to be meaſured.

1. Draw from the Point A, which ſtands for the Foot of the Mountain, a right Line, thirty-ſix Feet long, as AC.

2. Set the Inſtrument upon the Point A, and look through the two fixed Sights towards the Point C, and through the two movable ones towards the Point B, the Top of the Mountain; this Angle, for Inſtance, may be 110 Degrees.

3. Then ſet the Inſtrument upon C, and look through the two fixed Sights upon the Foot A, and through the two other fixed ones upon the Top B: Then compute the Angle, which may be, for Inſtance, forty Degrees.

4. Afterwards draw a Line upon Paper thirty-ſix Feet long, becauſe it ought to be equal to the Line AC, as DE.

5. Then with your Inſtrument at the Point D make an Angle equal to that of the Figure at A, *viz.* 110 Degrees, as GDF.

6. Upon the Point E, ſet another Angle of forty Degrees, equal to that at C, as IEH.

7. Produce the Sides DF and EI, and where theſe lengthened Lines interſect one another, as at K, draw from that Point to D a right Line, which will repreſent the Inclination which was required, provided the Height of the Staff upon which the Aſtrolabe was faſtened, be added.

V. *To meaſure the Vertical Height of a Mountain.*

This Problem muſt be wrought as the foregoing one, provided that you let fall a Perpendicular from the Point K, which marks the Top of the Mountain, which muſt touch the Line C D produced to L; the Line K L will repreſent the vertical Height of the Mountain.

VI. *To meaſure the Height of a Tower built upon a Rock.*

Let the Height B D be to be meaſured.

1. Seek the inclining Height of the Mountain by *Prob.* 4. and let the Triangle A B C ſerve for its Operation.

2. Make the Triangle H I K upon Paper equal to the Triangle A B C.

3. Meaſure the Field-Angle C B D, for Inſtance thirty-eight Degrees.

4. Upon K, which repreſents the Point B, and ſo by conſequence the Top of the Mountain, raiſe a Perpendicular of what Height you pleaſe.

5. With your Inſtrument make upon the Point an Angle equal to the Angle of the Figure A B C D, *viz.* L I M.

6. Lengthen the Side I M till it touches the Perpendicular raiſed upon K in N.

7. Meaſure the Line N K, it will give you the Height of the Tower B D, if you add to it the Height of the Staff.

VII. *To*

VII. *To take the Depth of a Well.*

1. Meaſure its Diameter AB, nine Feet for Inſtance; and find the Angle ABE of ninety Degrees.

2. Set the Inſtrument ſo upon A, as that by the two fixed Sights you may ſee the Point B, and by the two movable ones you may ſee the Bottom of the Pit E, and let this Angle be ſixty Degrees, as HAI.

3. Draw a Line nine Feet long upon Paper, which ſhall repreſent the Diameter AB, as FG.

4. From F let fall a Perpendicular which may repreſent the Depth BE.

5. Make an Angle at G equal to the Angle KGL, *viz.* of ſixty Degrees, as HAI.

6. Lengthen the Side GL, and where this lengthened Line meets the Perpendicular F, in M, meaſure from M to F, and you will have the Depth of the Well.

CHAP. II.

Of meaſuring of Diſtances.

MEaſuring of Diſtances, is a Science which teaches to meaſure the Diſtance of one Place from another, in an open Field.

PROBLEMS.

I. *To meaſure the Diſtance of one Place from another, where they are both acceſſible.*

Let the Diſtance from A to B, be to be meaſured.

1. From A draw a right Line, what you pleaſe, and meaſure with a Chain or Scale; ſuppoſe twenty-two Feet in Length, as A C.

2. Set the Staff upon which the Aſtrolabe is fixed upon the Point A, ſo as that by the two fixed Sights you can only ſee directly forward towards the Point C, and by the two others the Point B: Then count the Angle d A e, ſuppoſe ninety Degrees.

3. Remove the Inſtrument upon C, and look through the fixed Sights towards A, and through the movable ones towards B; then compute this Angle f c g, ſuppoſe twenty-two Degrees.

4. Draw a Line upon Paper twenty-two Feet long, equal to the Line AC, as HI.

5. With the Reporter upon the Point H draw an Angle equal to the Angle d A e, that is to ſay, of ninety Degrees, as k H l: Do the ſame Thing at I, where make another Angle equal to the Angle e f g, *i. e.* of twenty-two Degrees, as m I h.

6. Lengthen the Sides HK, IM, and from the Point where theſe two lengthened Lines interſect each other, as O, to the Point H, meaſure the Diſtance, which ſhall be equal to the Length AB.

II. *To meaſure the Diſtance of two Places, whereof one is inacceſſible.*

Let the Diſtance from A to B be that which is required, and B inacceſſible, becauſe of a River which hinders all Approaches.

1. From A draw a right Line twenty-two Feet long, as AC.

2. Set your Inſtrument upon A, and look thro' the two fixed Sights upon the Point C, and thro' the two movable ones upon B: Then compute the Angle D A E of ninety-three Degrees.

3. Carry the Inſtrument to C, and look through the two fixed Sights upon the Point A, and through the two others upon B, and then compute the Angle F C G of thirty-three Degrees.

4. Draw upon Paper a Line equal to A C, *i. e.* of twenty-two Feet, as H I.

5. Upon H make an Angle equal to the Angle of the Figure D A E, *i. e.* of ninety-three Degrees, as K H L: So alſo upon I make another Angle equal to the Angle F C G, as M I N.

6. Lengthen the Sides H K and I M, and in the Place where they interſect, as at O, let fall a Perpendicular upon H, which will give you the Diſtance A B.

III. *To find the Diſtance of two Places which are both inacceſſible.*

Let the Diſtance A B be to be meaſured.

1. Take a fixed Point C, from which draw a right Line C D, which ſhall be thirty-three Feet long.

2. Set the Inſtrument upon C, and look through the two fixed Sights upon the Point D, and thro' the two others upon the Point A: Then compute the Angle K C H, for Inſtance of ninety Degrees.

3. Leave the Inſtrument as it is, and remove the movable Sights, till through them you may ſee the Point B, and then compute that Angle, for Inſtance thirty-ſix Degrees, as i C H.

4. Carry the Inſtrument to D, and fit it ſo, as that thro' the fixed Sights you may ſee the Point

C, and through the two other movable ones the Point B: Then compute this Angle, which may be of 100 Degrees, as g D E.

5. Leave the Inſtrument as it is, and turn the movable Sights till you may ſee the Point A thro' them; then compute that Angle, of thirty Degrees, as f D e.

6. Afterwards draw a Line of thirty-three Feet upon Paper, to repreſent the Line C D, as L M.

7. With the Reporter ſet two Angles at L, one of ninety Degrees, and the other of thirty-ſix Degrees, ſo that the firſt n L O may repreſent the Angle H C K, and the other N L P the Angle I C H.

8. Lengthen the Sides L O and L P.

9. Add two Angles to the other Point N, one of 100 Degrees, as q m r to repreſent the Angle of the Figure E D G, and the other of thirty Degrees, as q M S, to repreſent the Angle e D F.

10 Lengthen the Sides M R, M S, and obſerve where theſe two lengthened Lines touch the two firſt, as at T V. For this Diſtance T V will give you the Diſtance A B, which is required.

IV. *To meaſure the Breadth of a River with a Staff.*

1. Fix a Staff perpendicularly upon the Bank of a River, as A.

2. Cleave it at the End, and faſten a Croſs-Staff into the Cleft, as B C.

3. Stand behind the ſmall Croſs-Staff B C, and uſe it as you would the Sights of an Aſtrolabe, *i. e.* move it downwards, till from B C you can ſee the other Side of the River at P A.

4. Afterwards letting the ſmall Staff ſtand as it is, turn the large one perpendicularly, till from

B C you can ſee the whole Length of the Bank: Then ſtand behind B, and obſerve the laſt Place, where from C you can ſee the Bank on the other Side, as at E.

5. Meaſure the Diſtance E A, it will give you the Breadth of the River A D.

V. *To deſcribe a Figure taken from the Field upon Paper.*

Let the Figure to be deſcribed be A B C D E.

1. Set the Staff to which the Aſtrolabe is fixed, upon the Point E, and look upon the Point D through the fixed Sights, and through the two movable ones upon the Point A. Then compute this ſingle Angle A E D, ſixty Degrees, for Inſtance.

2. Meaſure the Line A E of twenty-three Feet.

3. Meaſure another Line E D of twenty-three Feet.

4. Set the Inſtrument upon D, and look towards C with fixed Sights, and with the movable ones towards E: Then compute this Angle, of ſeventy Degrees, for Inſtance, as C D E.

5. Let the Side D C be of twenty-eight Feet.

6. Seek the Angle b C d after the aforeſaid Manner, and let it have fifty Degrees.

7. Meaſure the Line C B, for Inſtance, of thirteen Feet.

8. The Side B A will be found of itſelf.

When this is done in the Field, then

1. Draw a Line upon Paper twenty-three Feet long, to repreſent the Figure A E, as K F.

2. With your Inſtrument make at the Point F an Angle equal to the Angle of the Figure d E a, *i. e.* of ſixty Degrees, as K F G.

3. Lengthen the Side of this Angle F g, and add its Length to it, *i. e.* twenty-four Feet, as F G.

4. Upon G make an Angle equal to that of the Figure e D c, *i. e.* of ſeventy Degrees, as f G h.

5. Lengthen the Side G h, and add the Side D C, *i. e.* of twenty-eight Feet, as G H.

6. Upon the Point H ſet another Angle equal to that of the Figure d C b of fifty Degrees, as g H i.

7. Lengthen the Side H i, and add thirteen Feet to it, as H I, which may repreſent the Side C B.

8. Join I K together by a right Line, which will give the laſt Side of the Figure B A, and which at the ſame Time will entirely repreſent the given Figure upon Paper.

VI. *To deſcribe upon Paper a Figure taken from the Field, which is inacceſſible.*

Let the Figure A B C be to be deſcribed upon Paper from the Point D.

1. From D draw a Line D E thirty-two Feet long.

2. Set the Inſtrument upon D, and look through the fixed Sights towards E, and through the two movable ones towards A: Then compute the Angle g D f, of 105 Degrees.

3. Leave the Inſtrument as it is, and remove the movable Sights till you can ſee the Point B, and compute the Angle g D h of ninety Degrees.

4. Leave the Inſtrument ſtill as it is; look through the movable Sights towards the Point C, and compute the Angle g D i of ſixty Degrees.

5. Set the Inſtrument upon E, and look through the fixed Sights towards the Point D, and through the movable ones towards A, and compute the Angle k E l, for Inſtance, of fifty Degrees.

6. Leave the Inſtrument as it is, and look through the movable Sights towards B, and compute this Angle m E k of ſeventy Degrees.

7. Look through the ſame Sights towards the Point C, and then compute the Angle k E n, for Inſtance, of ninety Degrees.

This being done in the Field, then

1. Draw a Line of thirty-two Feet upon Paper, as O P, equal to the Line D E.

2. Take an Angle of 105 Degrees at O, as q O r, which may repreſent the Angle of the Figure f D g, and lengthen the Side O q.

3. Leave the Reporter as it is, and compute another Angle of ninety Degrees, as r O s to repreſent the Angle g D h, and lengthen the Side O s.

4. Seek the laſt Angle of ſixty Degrees r O t, which may repreſent the Angle of the Figure g D I, and lengthen the Side O t.

5. Set the Reporter upon the Point P, and compute an Angle of fifty Degrees, to repreſent the Angle l E k, as a P b; lengthen the Side P b till it meets with the Side O q in C: For this Point of Interſection will mark the Point A.

6. Leave the Reporter as it is, and compute another Angle of ſeventy Degrees, which may repreſent the Angle m E k, as a P d; lengthen the Side P d till it cuts the lengthened Line O s in E, which Point will mark the Point B in the Figure.

7. Compute another Angle of ninety Degrees equal to the Angle n E k, as P f; lengthen the Side P f till it meets with the lengthened Line O t in G, which anſwers to the Point C in the Field-Figure.

8. Join CE, EG, and GC together, and you ſhall have your Figure ABC repreſented upon Paper.

CHAP. III.

Of meaſuring of Plains.

MEaſuring of Plains is a Science which teacheth us to meaſure all Sorts of Surfaces of Things, which Geometricians call *Areas*.

PROBLEMS.

I. *To meaſure the Area of a right-angled Triangle ABC.*

1. Meaſure the Line AB, twelve Feet long for the Baſe.
2. Meaſure the Perpendicular BC, of eight Feet.
3. Multiply the half of the Baſe by the whole Perpendicular, or the half of the Perpendicular by the whole Baſe, by the Sum (forty-eight Feet) will be the Area of the Triangle which was deſired.

II. *To meaſure the Area of an oblique-angled Triangle DEF.*

1. Let fall a Perpendicular from F to its oppoſite Side DE, which may divide the Triangle into two right-angled Triangles, DGF, and FGE.
2. Meaſure theſe two Triangles by the foregoing Problem, *i. e.* multiply the whole Baſe DG and GE by the half of the Perpendicular FG, or the whole Perpendicular by the half of the Baſes DG and DE.

Thus for Inſtance: Let the Baſe DG be twelve Feet, and the Perpendicular FG ten. Take the half of the Perpendicular, *i. e.* five Feet, and multiply it by the Baſe of twelve Feet, and the Sum will be ſixty Feet, which gives the Area of the Triangle DFG.

3. Let the Baſe GE of the Triangle FGE be ſix Feet, and the Perpendicular FG ſtands as it did, *i.e.* to Feet. Multiply five by ſix, or three by ten; the ſum will be thirty Feet, which will give the Area of the Triangle. Then add thirty to ſixty, the Sum ninety will be the Number of Feet in the whole Area of the given Triangle DEF.

III. *To meaſure the Area of an equilateral right-angled Square ABCD.*

Multiply one Side by the other. AB for Inſtance, of twelve Feet, by BC of twelve Feet, becauſe the Sides are equal: The Product 144 Feet will give you the Area which is ſought for.

IV. *To meaſure the Area of a Parallelogram ABCD.*

Multiply the ſhorteſt Side BC of ſix Feet, by the longeſt Side AB of twelve Feet: The Product ſeventy-two Feet will give you the Area of the Parallelogram which was required.

V. *To find the Area of a Rhomb, ABCD.*

1. Let fall a Perpendicular from A to the Line DC, as AE.

2. Let fall another Perpendicular from B equal to AE, as BF; and join CF together. So that

inſtead of a Rhomb you have a Parallelogram A B E F: Then work by the foregoing Problem. See *Prob.* 28. *Book* 1. *Chap*, 2.

VI. *To find the Area of a Rhomboid ABCD.*

1. Let fall a Perpendicular from A to the oppoſite Line D C, as A F.
2. Let fall another from B, equal to A F, as BE.
3. Join C E together, and inſtead of the Rhomboid ABCD you have a Parallelogram ABEF: You will find its Area by the fourth Problem of this Chapter.

VII. *To find the Area of any unequilateral Quadrangle.*

Let the given Quadrangle be A B C D.

1. Divide this Quadrangle into two Triangles A B D, and C D B.
2. Divide each of theſe Triangles into two right-angled ones, as ABF, BCE, ADF, DEC.
3: When you have theſe four right-angled Triangles, ſearch their Areas by the two firſt Problems of this Chapter: Then join the Sum of all theſe Triangles together, and it will give the Area which is required.

VII. *To find the Area of any regular Polygon.*

Let the regular Pentagon demanded be ABCDE.

1. Meaſure one Side of the Polygon as A B, for Inſtance, ſix Fathoms: Multiply this Number by the Number of the Sides of the Polygon, as here by five, becauſe this Polygon has but five Sides: The Product of this Multiplication will give you the Length of all the Sides.

2. Let fall a Perpendicular from any Side to F the Center of the Polygon, as F G: Then meaſure this Line, five Fathoms, for Inſtance.

3. Multiply the Sum of all the Sides, by the half of the Perpendicular: The Product will give the Area which is required.

IX. *To find the Area of any irregular Polygon ABCDE.*

1. Divide the whole Figure into right-angled Triangles; as this irregular Pentagon A B C D E into ABG, BCG, ADH, CDH, AEF, and DEF.

2. When you have only right-angled Triangles, work by the firſt Problem of this Chapter; the Sum of all the Triangles reduced to one, gives the Area which is ſought for.

X. *To find the Area of a Circle.*

Reduce this Circle to a right-angled Triangle, by *Prob.* 21. *Book* 1. *Chap.* 2. and then ſeek the Area by the Rules of the firſt Problem of this Chapter.

XI. *To find the Area of an oval Figure.*

1. Divide the propoſed Figure into four equal Parts, as A B C D, ſo as that the Line A B may make one Diameter, and C D another.

2. Seek for a mean Proportional between theſe two Diameters; which you may thus find:

Set the Diameter A B upon a long Line, and upon the ſame Line from the Point B ſet the other Diameter C D, as B C; then take the half of the Diſtance between A and C, and carry it on to B, as E B; this ſhall be a mean Proportional;

then divide E B into two equal Parts, as E F, F B; then draw a Circle from the Point F through the Point E B, which ſhall be equal to the given oval Figure.

3. Having this Circle, find its Area by the foregoing Problem, *i. e.* raiſe a Perpendicular upon B, one extreme Point of this Diameter, which ſhall have thrice the Length of the Diameter A B, and a ſeventh Part over, as B G.

4. Join F the Center of the Circle to the Point G by a right Line, which ſhall give a right-angled Triangle equal to the given Circle; its Area may be found by the Rules of the firſt Problem of this Chapter.

[This Triangle which he ſays is equal to the Area of the Circle is not expreſſed in the Scheme.]

XII. *To meaſure the Surface of any equilateral Pyrrmid.*

1. Let ABCD be an equilateral Square, which ſhall be the Baſe of the Pyramid given.

2. Find the Area of this Baſe by Prob. 3. of this Chapter, of forty-eight Feet.

3. Multiply one of its Sides, as A B, by the Height of the Pyramid E F, that is 12 by 28, whoſe Product will be 336 Feet.

4. Multiply 336 by 4, the Number of the Sides of this Pyramid, and the Product will be 1344 Feet.

5. To this Sum add the Area of its Baſe, forty-eight Feet, and you will have the total Sum of the Area of the Pyramid propoſed, *viz.* 1392 Feet.

XIII. *To find the Convex Surface of a right-lined Cylinder.*

1. Set the Height of the Cylinder B D upon a long Line.

2. Set upon the ſame Line, beginning at the Point D, the Diameter of the Baſe of the Cylinder marked C D, as D E.

3. Divide the Line E B into two equal Parts, B F, E F.

4. With the Diſtance F D draw a Circle, which ſhall contain the Convex Surface of the given Cylinder: This you may find by *Prob.* 21. *Chap.* 2. of the firſt Book, which teaches you to make a right-angled Triangle equal to a given Circle: When you have this Triangle, find its Area by *Prob.* 1. of this Chapter.

5. When you have the Area of this right-angled Triangle, which repreſents the Convex Surface of the Cylinder, then find the Area of the two Baſes of the Cylinder by *Prob.* 1. of this Chapter: Add the Sum of the two Baſes to the Area of that Triangle which gives you the Convex Surface of the Cylinder, without counting the Baſes, and you will have the general Sum of the whole Surface of the Cylinder, with both its Baſes. See *Archimedes de Sphærâ & Cylindro*, Lib. i. Prop. xiii.

XIV. *To find the Convex Surface of a regular Cone.*

Let the given Cone be A B D, and its Diameter A D.

1. Set the Height of the Cone D B upon a right Line.

2. Set its Semi-diameter C D upon the ſame Line, as D E.

3. Divide E B into two equal Parts, E F, F B.

4. Take the Diſtance F D, and make a Circle in large as the Cone without the Baſe.

5. Reduce this Circle to a right-angled Triangle by *Prob.* 21. *Chap.* 2. of the firſt Book, and find its Area by *Prob.* 1. of this Chapter.

6. By the two forementioned Problems ſeek the Area of the Baſe of your Cone, and add this Sum to the former; the Sum total will give the whole Surface of the given Cone. See *Archimed.* Lib. cit. Prop. xiv.

XV. *To meaſure the Convex Surface of a Globe.*

1. Meaſure the Diameter A B, of nine Feet.

2. Find the Circumference of the Circle, whereof that is the Diameter, which is always thrice as long, and a third Part over.

3. Multiply the Diameter by the Circumference; the Product will give you the required Surface of the given Globe.

XVI. *To find the Area of any Trapezium as ABCD.*

You muſt work by the Rules of Problem 7. of this Chapter.

XVII. *To find the Area of the Baſe of a round Tower, where you can only come at one Part.*

1. Meaſure the Line A B, of fourteen Fathoms, and from its middle Point draw a Perpendicular to the Arch, as DC, of four Fathoms.

2. Multiply the Diſtance AD by the Remainder DB, *i. e.* 7 by 7; then divide by 4 the Number of the Perpendicular DC.

3. Add to this the Length of the Perpendicular, *i. e.* four Fathoms, and it will give you the Length of the Diameter, to compleat the Baſe.

4. When you have found the Baſe, ſeek for a right-angled Triangle equal to it, by Prob. 21. Chap. 2. Book 1; afterwards you may find the Area of that Triangle by Prob. 1 of this Chapter.

CHAP. IV.

Of meaſuring of Solids.

MEaſuring of Solids is a Science which ſhews how one is to find the Solidity of Bodies: Solidity is Magnitude with Breadth, Length, and Thickneſs.

PROBLEMS.

I. *To find the Solidity of a Parallelepiped.*

1. Meaſure the Height, Length and Breadth of the Parallelepiped.

2. Multiply the Breadth A D, of two Feet, by the Length A B, of four Feet, and the Sum will give you the Area of the Baſe.

3. Multiply the Number of this Area by the Height of the Parallelepiped, which here ſhall be eight Feet; and the Product from thence will ſhew you the Solidity required, of ſixty-four Feet.

II. *To find the Solidity of a Priſm.*

1. Find the Area of the Baſe ABC, by Prob. 2. Chap. 3. Book 2. of ſix Feet.

2. Meaſure the Height CF, here of nine Feet.

3. Multiply the Baſe by its Height, *i. e.* 6 by 9, and the Product 54 will give the Solidity required.

III. *To find the Solidity of a Cylinder.*

1. Find the Area of the Baſe by Prob. 21. Book 1. Chap. 2. and by Prob. 1. Chap. 3. Book 2. for Inſtance five Feet.

2. Find the Height of the Cylinder A B, here of nine Feet.

3. Multiply the Area upon the Height, *i. e.* 5 by 9, and the Sum 45 will give the Solidity required.

IV. *To find the Solidity of Pyramids and Cones.*

1. Meaſure their Height F E and A B, for Inſtance, of twelve Feet.

2. Find the Area of their Baſes; that of the given Pyramid by Prob. 6. Chap. 3. Book 2. of ſixteen Feet; and that of the Cone by Prob. 10. Chap. 3. Book 2. of ſixteen Feet.

3. Multiply the entire Height by the third Part of the Baſe, *i. e.* twelve Feet by five Feet four Inches; or the whole Baſe by the third Part of the Height, *i. e.* ſixteen Feet by four Feet; the Sum ſixty-four Feet will give the Solidity of the Pyramid and the Cone; for this is equal to the given Pyramid: And becauſe we are to find its Solidity, that alſo will be equal to the Solidity of the ſame Pyramid.

V. *To find the Solidity of a Globe.*

1. Multiply the Semi-diameter A B by the Surface of the Globe, which you ſhall find by Problem 15. of the foregoing Chapter.

2. Divide this Sum by 3, and the Quotient will give you the required Solidity: For Inſtance, let the Semi-diameter be 28 Feet, and the Convex Surſace 9856 Feet; multiply this by 28, and the Product will be 275968; divide that by 3, and your Quotient 91989$\frac{1}{3}$ will give you the Number of Feet which make up the Solidity of this Globe.

VI. *To find the Solidity of a Tetraëdron.*

Since a Tetraëdron is nothing elſe but a Triangular equilateral Pyramid, its Solidity muſt be ſought by Prob. 4. of this Chapter, *i. e.* by multiplying the Baſe by a third Part of the Height, or the Height by a third Part of the Baſe; the Product will ſhew the Solidity which is required.

VII. *To find the Solidity of an Octaëdron.*

Since an Octaëdron is made up of two Pyramids which have one common Baſe, *i. e.* an equilateral right-angled Square,

1. Find the Solidity of one of theſe Pyramids by Prob. 4. of this Chapter, for Inſtance of ſixteen Feet.
2. Multiply theſe 16 Feet by 2, the Product will give the required Solidity of 32 Feet.

VIII. *To find the Solidity of a Dodecaëdron.*

If one draws from the Center of a Dodecaëdron a right Line to every angular Point, one may form twelve equal Pyramids, every one whereof will have a regular Pentagon for its Baſe; upon which Account,

1. Find the Solidity of one of theſe twelve Pyramids, by the ſame fourth Problem; and let it be, for Inſtance, of twelve Feet.

2. Multiply theſe twelve Feet by the Number of the Pyramids, *i. e.* 12; the Product 144 gives the required Solidity.

IV. *To find out the Solidity of an Icoſaëdron.*

This being formed of twenty equal *Tetraëdra*, if one draws right Lines from its Center to every angular Point, one muſt,

1. Find the Solidity of one of theſe *Tetraëdra* by the ſame fourth Problem, for Inſtance, of eight Feet.

2. Multiply 8 by 20, the Number of the *Tetraëdron*; and the Product 160 will ſhew the Number of the ſolid Feet in the given *Icoſaëdron*.

X. *To find the Solidity of a Cube.*

By the third and fourth Problems of the foregoing Chapter, multiply the Area of the Baſe by the Length, and the Product gives the Solidity.

XI. *To find the Solidity of a ſolid Rhomb, and Rhomboid.*

Find the Area of a Baſe of a Rhomb by Prob. 5. of the foregoing Chapter, and the Area of the Baſe of the Rhomboid by Prob. 6. of the ſame: When they are found, multiply them by their reſpective Lengths, as was directed in the foregoing Problem, and the Product gives the Solidity required.

XII. *To find the Solidity of a Wall, Rampart, Curtain,* &c.

This is done by Problem 1. of this Chapter.

CHAP. V.

Of meaſuring Concave Bodies.

MEaſuring Concave Bodies is a Science which teaches us to find their Capacity, that ſo we may know how much they contain: Cylindrometrical Bodies have need of a Cylindro-metrical Scale; and Cubo-metrical Bodies have need of a Cubo-metrical Scale: So that theſe two Scales are made uſe of in the meaſuring of Concave Bodies.

PROBLEMS.

I. *To find the Capacity of a Concave Parallelepiped.*

By which I underſtand all ſquare Bodies; as Chambers, Granaries, Cellars, Towers, Pits, *&c.* So that if one would know how much they contain, he muſt,

1. With his Cubo-metrical Scale meaſure the Height, Length, and Depth.
2. Multiply the Length by the Breadth, and their Product by the Height.
3. Examine how many Meaſures the whole Sum takes up upon the Scale, and ſo the required Capacity may be found.

II. *To find the Capacity of a Ditch.*

1. Meaſure its Breadth at the Top, AF, fifteen Fathoms and one Foot.

2. Meaſure its Breadth at the Bottom CD, eleven Fathoms five Feet.

3. Meaſure its Depth CG, nine Fathoms.

4. Meaſure its Length, 496 Fathoms.

5. Add the two Breadths together, and multiply the half of the Sum by the Length of the Ditch; there will be 6438 Fathoms.

6. Multiply theſe 6438 Fathoms by the Depth 9 Fathoms, and the Product will be 57942 Fathoms, or 347652 Feet, which gives the Capacity required.

III. *To find the Capacity of Columns, Towers, and other Priſms.*

1. With a Cubo-metrical Scale meaſure the Height of the Priſm.

2. Find the Area of the Baſe.

3. Multiply that Number by the Height, and you will find the Capacity.

IV. *To find the Capacity of any regular Pyramid.*

1. Meaſure the Area of the Baſe with a Cubo-metrical Scale.

2. Meaſure the Height likewiſe the ſame Way.

3. Multiply the Height by the Area of the Baſe.

4. Divide the Product by three, and the Quotient will give you the Capacity.

V. *To find the Capacity of a Cone.*

1. Meaſure the Area of the Baſe with a Cubo-metric, or Cylindro-metric Scale.
2. Multiply this Number by the third of the Height, and you have the Solidity.

VI. *To find the Capacity of a Cylinder.*

1. With a Cylindro-metrical Scale find the Area of its Baſe.
2. Multiply that by the Height of the Cylinder; the Quotient gives its Capacity.

VII. *To find the Capacity of a Truncated Cone whoſe Vertex is cut off.*

1. Find the Area of each Baſe by the Cylindro-metric Scale.
2. Add the Sums together, and multiply its Height by the half of that Sum; the Quotient will give its Capacity.

VIII. *To find the Capacity of a Barrel whoſe Heads are equal.*

We muſt take Notice that the Rod by which a Veſſel is to be guaged, is marked with different Meaſures; and ſo one Side of the Guaging-Rod is r the Length of a Barrel, and the other for Depth: n anſwer therefore to the Queſtion propoſed,

1. Meaſure the Area of the Bottom AB.
2. Meaſure the Thickneſs with the Gauging-Rod, and by that take the Surface of the Belly of e Barrel.

3. Add theſe two Sums together, and multiply the half by the Length of the Veſſel, ſo the Product gives you its Capacity.

IX. *To find the Capacity of a Barrel whoſe Heads are unequal.*

1. Meaſure the Diameter of the Head A, and by this known Diameter meaſure its Surface.

2. Meaſure the other Diameter E F, and thereby find the Area of that Head.

3. Add theſe two Sums together.

4. Find the Depth of the Barrel C D, by which you find the Surface of its Circumference; by Prob. 22. Chap. 2. Book 1. and by Prob. 10. Chap. 3. Book 2.

5. Add the Sum of this Surface to the Sum of the two Heads; then multiply the half of all theſe added together, by the Length of the Barrel: This will give you the Capacity.

CHAP. VI.

Of TRANSMUTATION.

TRanſmutation is a Science which teaches us to encreaſe or diminiſh any given Figures, or to give them another Form. We ought to take Notice, that what is here ſaid of Figures, may alſo be underſtood of Bodies, when one would give them another Shape which they had not before: But ſince we produced ſomewhat of this Matter in Chap. 2. Book 1. from Prob. 21. to the End of the Chapter, we ſhall at preſent only treat of the Tranſmutation of Bodies.

PROBLEMS.

I. *To turn a Cylinder into a Parallelepiped of the ſame Height.*

1. Inſtead of the Baſe of the Cylinder C B A, make a Square A B C D, by Prob. 23. Chap. 1. Book 1.

2. Raiſe upon A B C D four Perpendiculars of the Height of A B, which may repreſent the Height of the Cylinder, as E F G H.

3. Join E F, E H, F G, and G H together by right Lines; and you have the Parallelepiped.

II. *To turn a Cone into a Pyramid of the ſame Height.*

1. Make a Triangle, Square, Pentagon, or what other Polygon you pleaſe, equal to the Baſe of the Cone C B D, and let it be the Baſe of a Pyramid, as A B C D.

2. Raiſe from the Middle of the Baſe F a Perpendicular, of the Height of the Cone B A, as F E; then draw from A B C D Lines to the Point, and the Pyramid is made.

III. *To turn a Parallelepiped into a Cylinder.*

Make a Circle equal to the Baſe of the Parallelepiped, and raiſe this Circle to be as high as the Parallelepiped, and the Work is done.

IV. *To turn a Pyramid into a Cone.*

1. Make a Circle equal to the Baſe of the Pyramid.

2. Raiſe upon its Center a Perpendicular as high as the Pyramid, as B A.

3. Draw the Extremities of the Diameter C D together till they meet at the Top of the Perpendicular A, and the Cone will be finiſhed.

V. *To turn a Priſm or a Cylinder into a Pyramid or a Cone of the ſame Height, or the contrary.*

1. Enlarge the Baſe of the Cylinder three Times as much as it is, by Prob. 1. Chap. 2. Book 1.

2. Upon its Center raiſe a Perpendicular as high as the Cylinder, and draw the Extremities of the Diameter together to the Top of the Perpendicular, and the Pyramid will be made: In like Manner you may turn a Cylinder or a Priſm into a Cone: On the contrary, when you would make a Priſm or a Cylinder equal to a Pyramid or a Cone, you muſt make the Baſe of the Pyramid or of the Cone three Times leſs, and then upon this Baſe erect a Cone or Pyramid of the Height of the Priſm or Cylinder given.

VI. *To make a Cube equal to a Parallelepiped.*

1. If the Baſe of the Parallelepiped be ſquare, find a mean Proportional between its Height and one Side of the Baſe; this mean Proportional will be the true Meaſure of the Cube required.

2. If the Baſe be only a Parallelogram, turn it into a Square by Prob. 25. Chap. 2. Book 1. then go on as at firſt, and your Work will be done.

VII. *To make a Cube equal to a Cylinder given.*

1. Make a Parallelepiped equal to a Cylinder given, by Problem 1. of this Chapter.

2. Afterwards make a Cube equal to that Parallelepiped, by the precedent Problem, and you have the Cube deſired.

VIII. *To make a Cube equal to a given Cone.*

1. Make a Parallelepiped equal to a given Cone, by Problem 5. of this Chapter.

2. Afterwards make a Cube equal to that Parallelepiped by Problem 6. of this Chapter.

IX. *To make a Cube equal to a Pyramid.*

This Problem muſt be wrought like the laſt foregoing.

X. *To make a Cone equal to a Globe.*

1. Take one of the great Circles of your Globe, and make it four Times bigger, by Prob. 11. Book 1. Chap. 2.

2. Raiſe a Cone upon this Baſe as high as the Semi-diameter of the Globe A B.

3. The Cone C D E will be equal to the Globe A B D.

XI. *To make a Cube equal to a given Globe.*

1. Make a Cone equal to a Globe, by the foregoing Problem.

2. Make a Parallelepiped equal to this Cone, by Prob. 5. of this Chapter.

3. Laſtly, make a Cube equal to this Parallelepiped, by Prob. 6. of the ſame Chapter.

Here we conclude our Treatiſe of *Geometry*, being perſuaded, that the Things which we have ſaid, will be enough for thoſe who would make any Progreſs in Fortification.

◆

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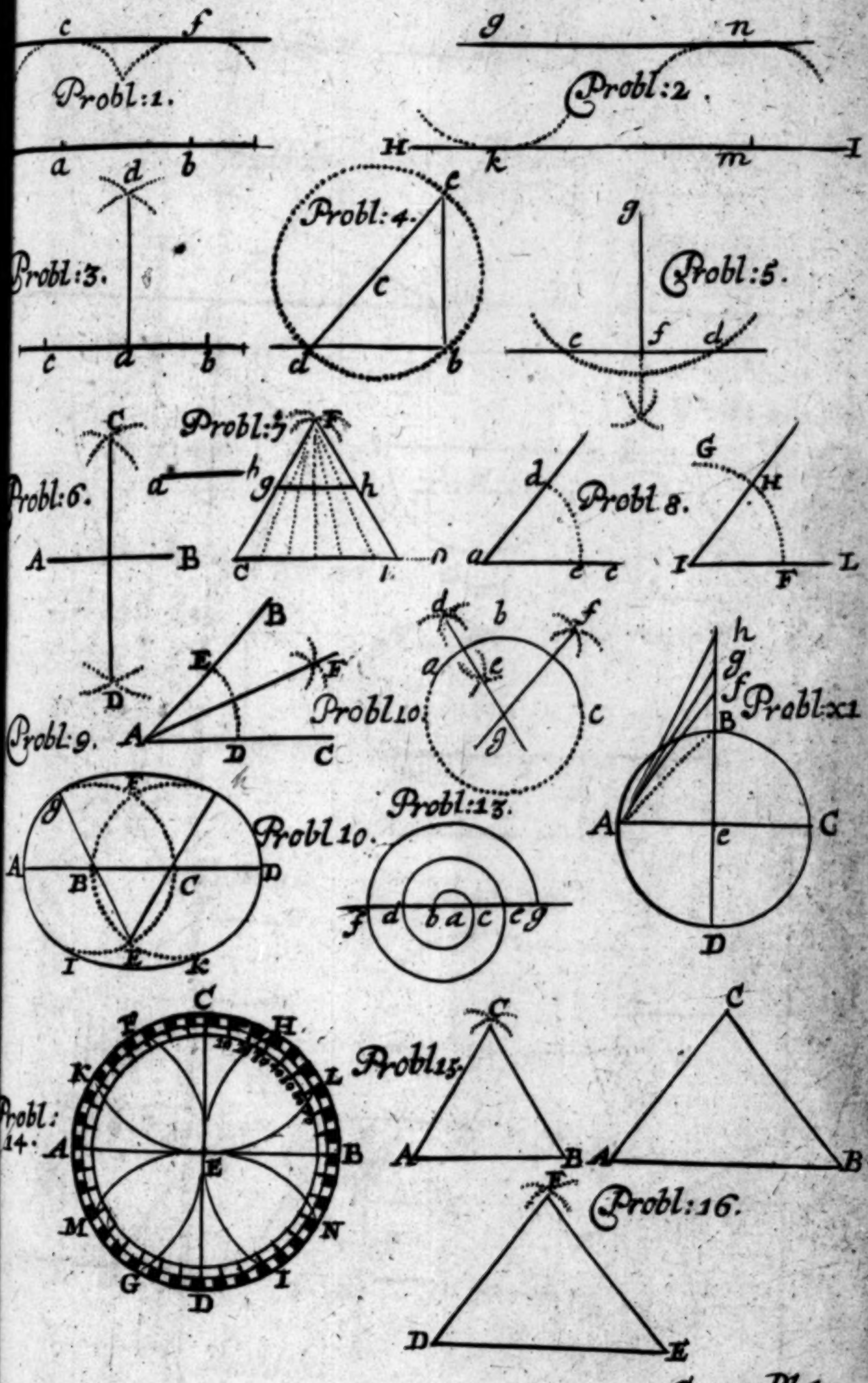
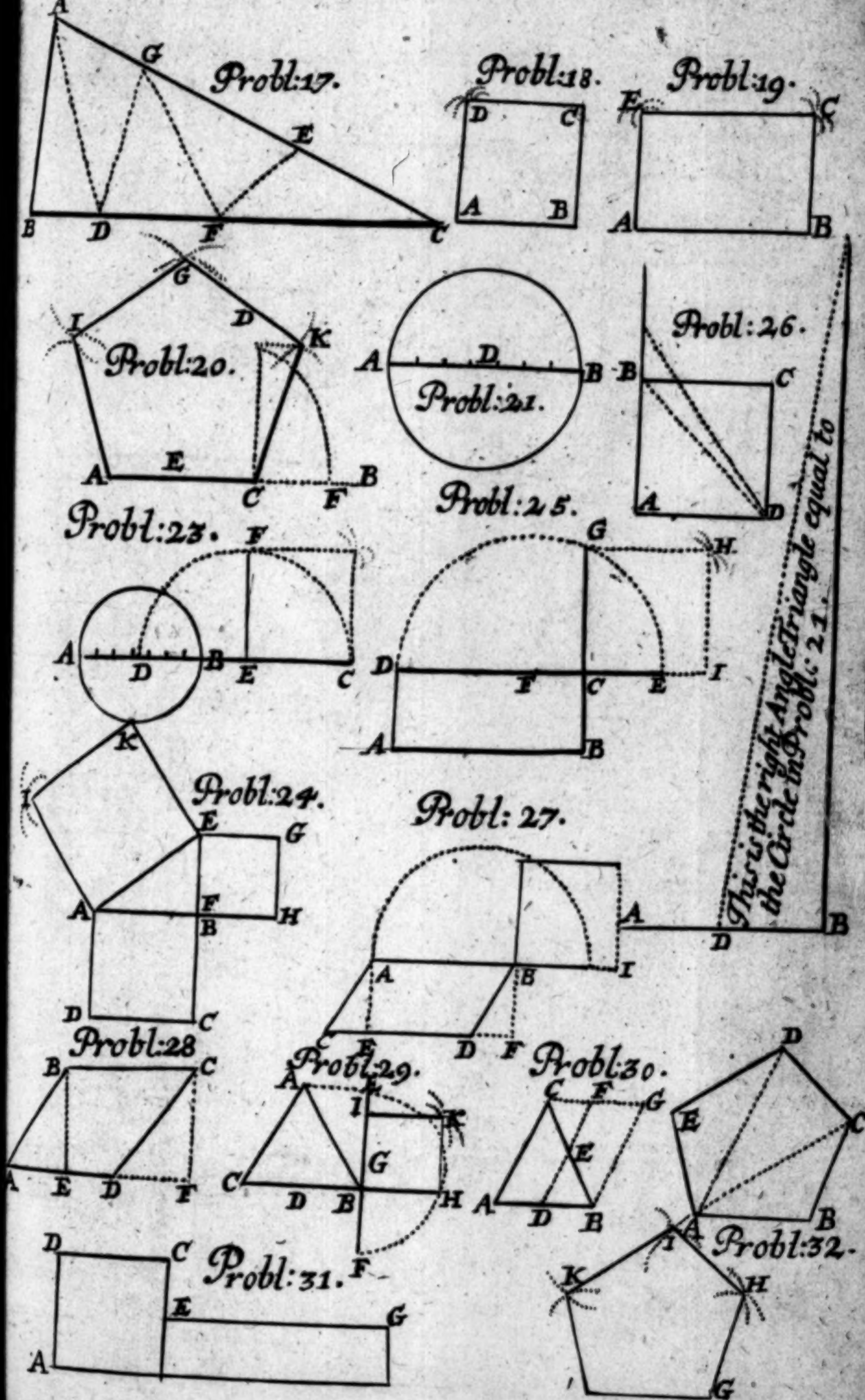


Geom:Pl:1.

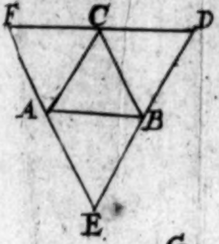
For Chap: 2. Book 1. Geom: Pl: 2.



This is the right Angle triangle equal to the Circle in Probl: 21.

For Chap: III Book: 1.

Probl: 1.



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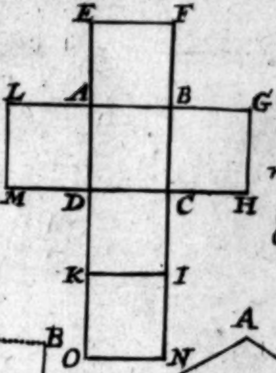

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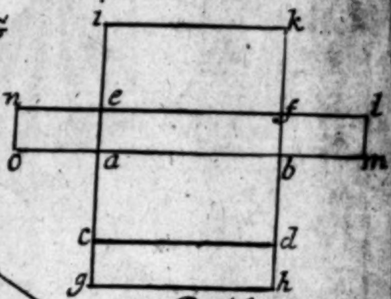

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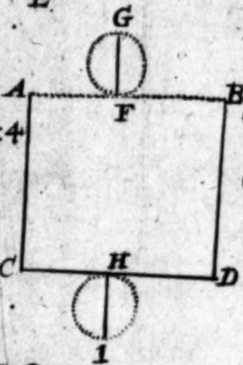

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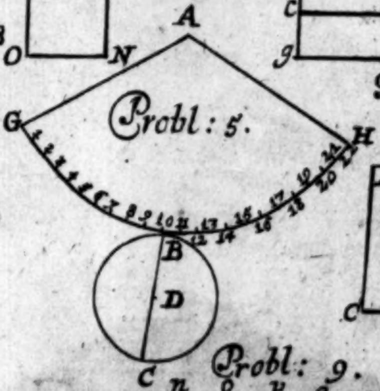

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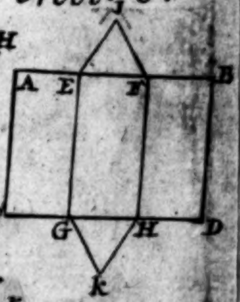

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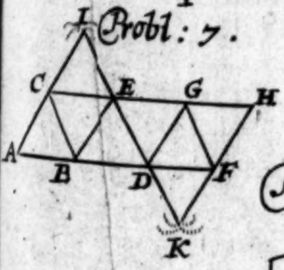

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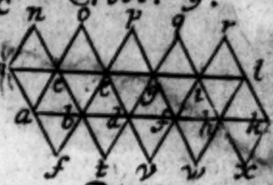

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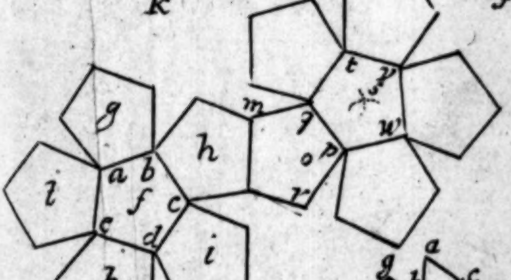

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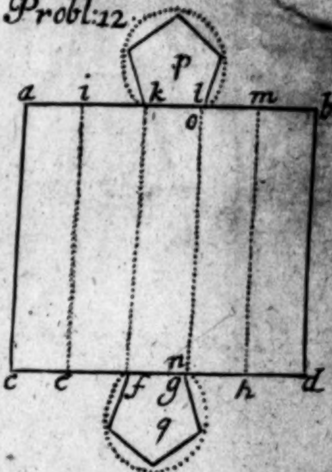

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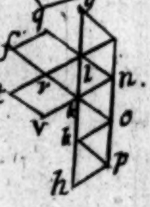

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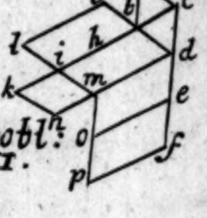
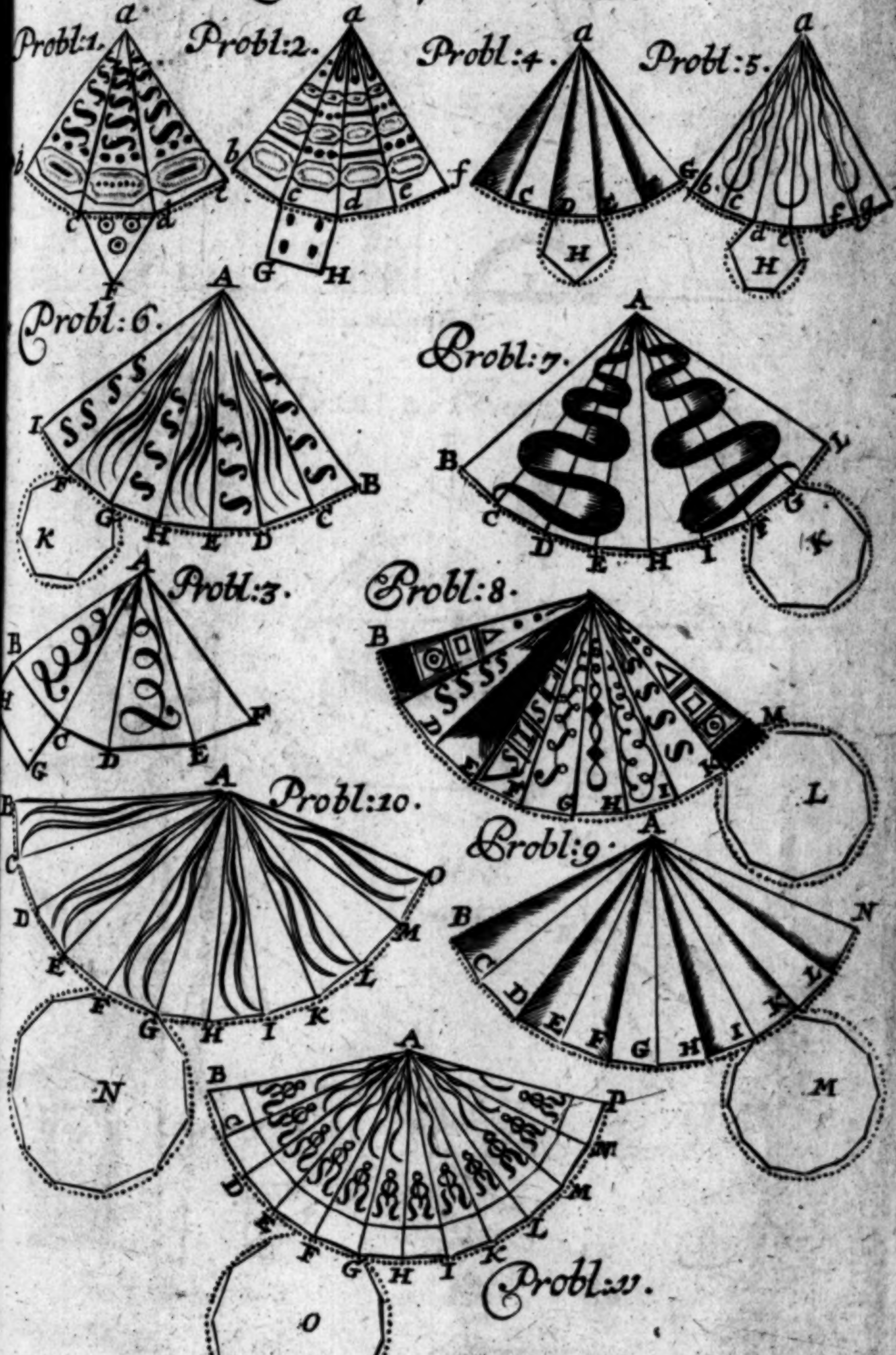


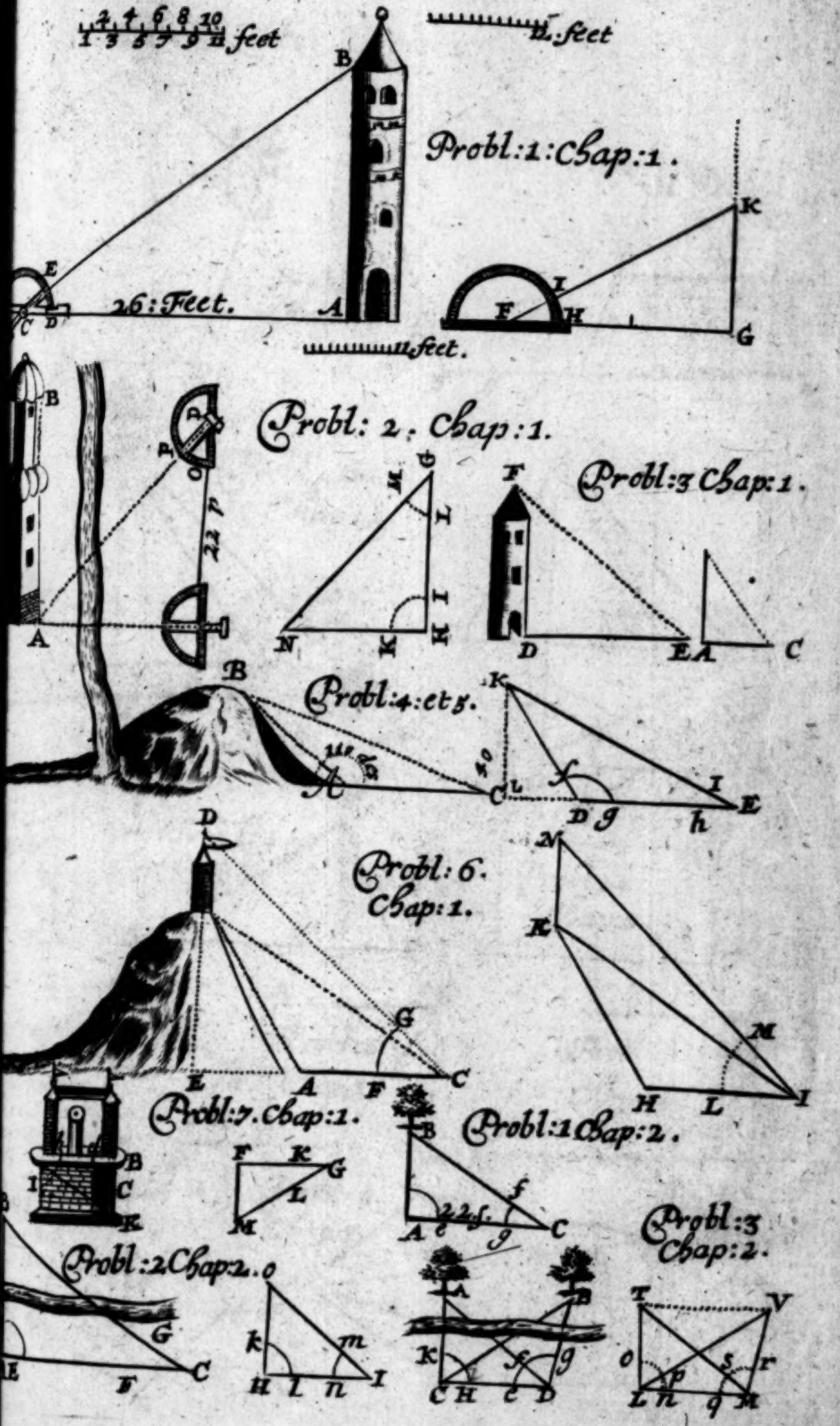
12

For: Chap: 4 Book: 1.



Geom: Pl: 4.

For Book:2. Geom:Pl:5.



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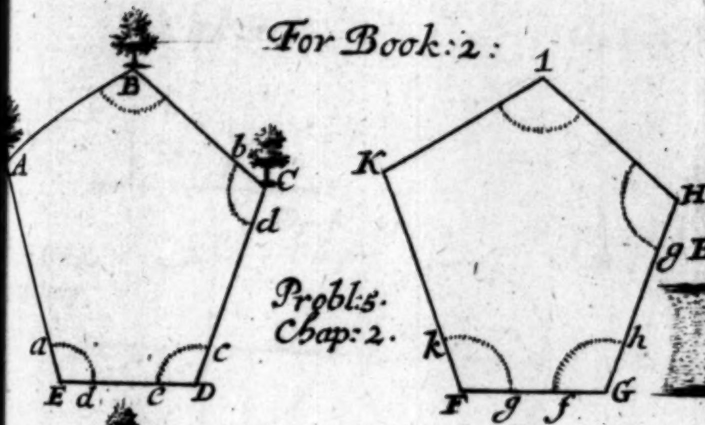
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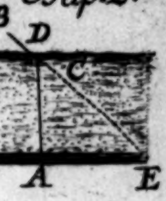
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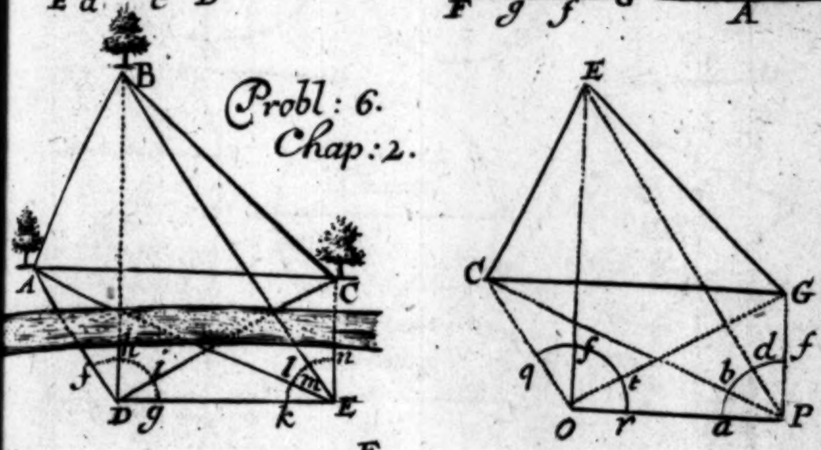
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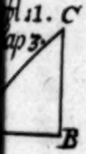
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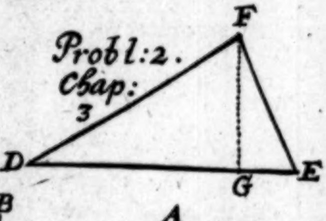
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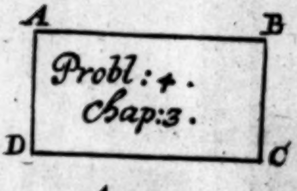
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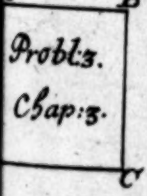
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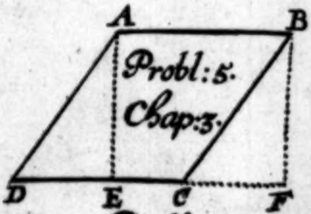
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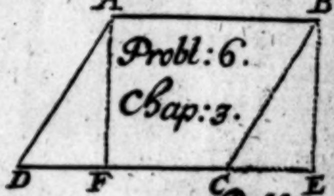
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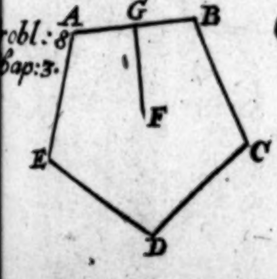
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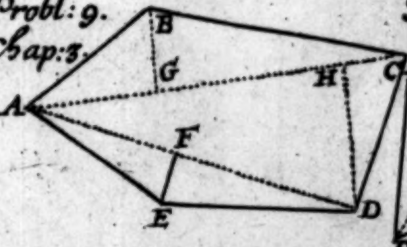
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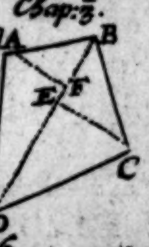
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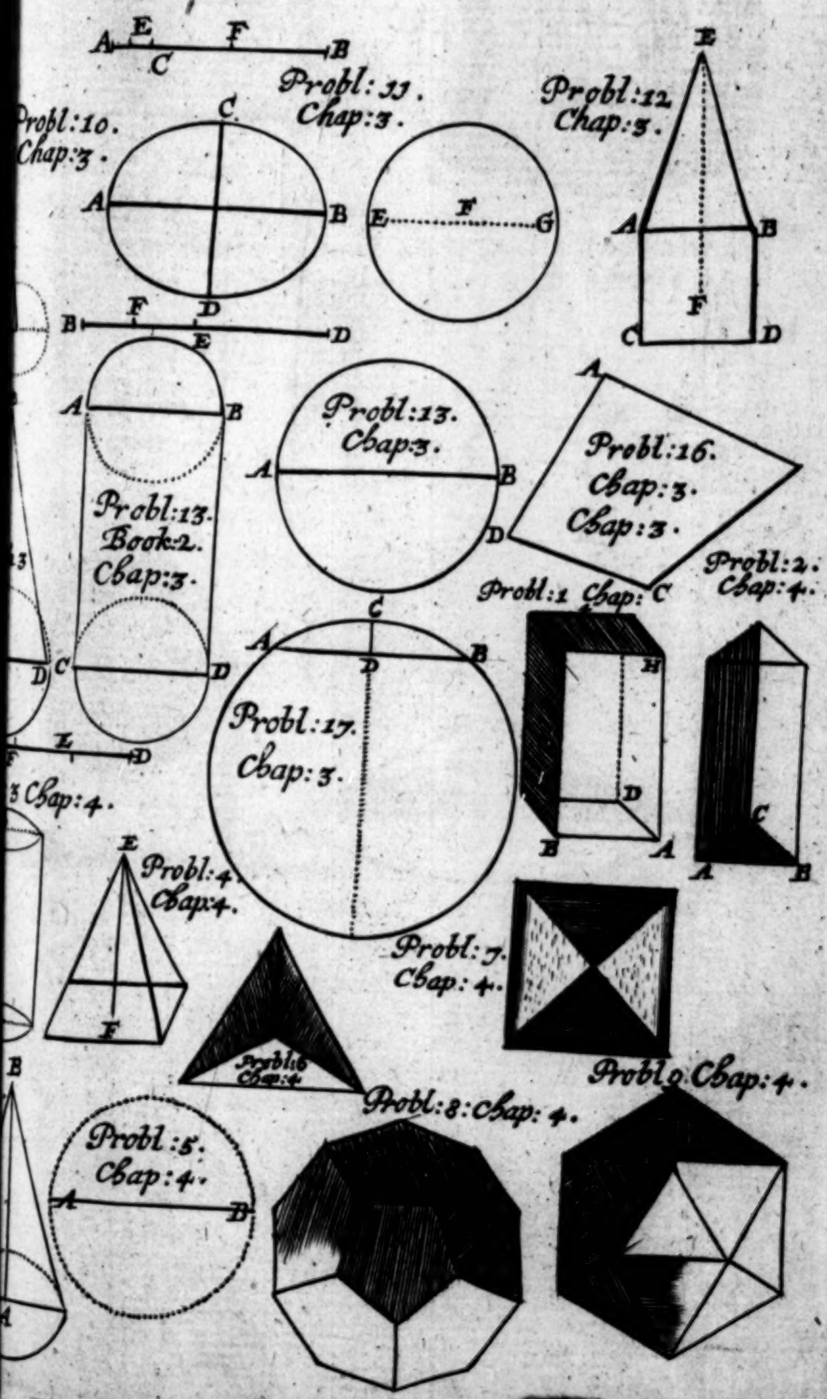

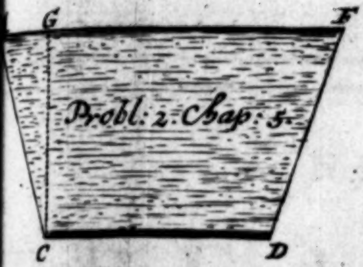
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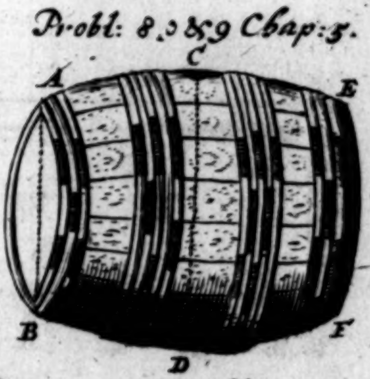
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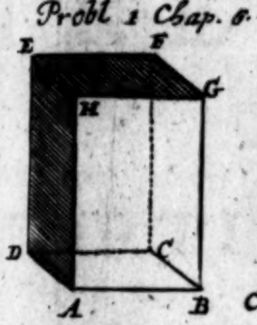
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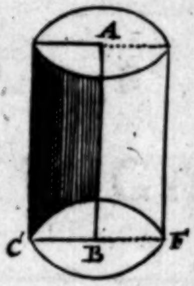
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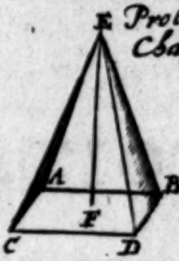
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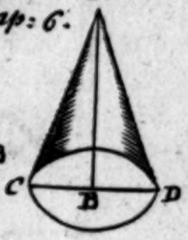
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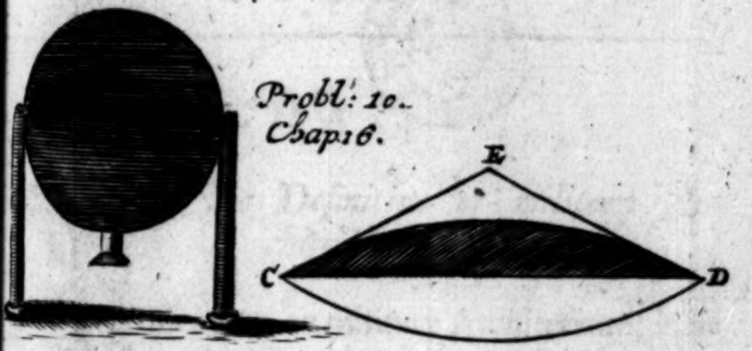
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A NEW TREATISE OF FORTIFICATION.

BOOK I.

CHAP. I.

Sect. 1. *Of the Definition of military Architecture.*

FOrtification, or military Architecture, is an Art which teaches Men to fortify themſelves with Ramparts, Parapets, Moats, Covert Ways and *Glacis*'s, to the End he Enemy may not be able to attack any Part ithout great Loſs of his Men; and that the ſmall Number of Soldiers which defend the Place may e thereof able to hold out for ſome Time.

Sect. 2. *Of the Original of Fortification.*

CErtain it is, that Fortification was origina ly very inconſiderable; for in regard th Men had nothing to fear at that Time but the A ſaults of wild Beaſts, and Robbers, they had n other Fortifications than ſimple Hedges, whic continued ſtill in Uſe 328 Years before our Saviou at what Time *Alexander the Great* found the *Hi canians* and *Mardians* fortified after that Manne *Q. Curtius*, Lib. vi. Cap. v. Afterwards they fo tified themſelves with Walls, thoſe Hedges bein eaſy to be cut down. But Ambition increaſing, i regard that they who coveted Dominion ove others, ſoon found a Way to leap over theſe feebl Defences, they added a Moat, and in making thi Moat they raiſed at the ſame Time a Rampart, behind which the Beſieged placed themſelves, to annoy the Enemy with their Arrows. The Enemy not able to ſurmount theſe Obſtacles, reſolved t venture ſome Arrows to paſs the Moat, and lodg themſelves at the Foot of the Wall, whence th Beſieged could not chace them, notwithſtandin the great Number of Stones which they threw down to annoy the Aſſailants, becauſe the Enemie covered themſelves with their Bucklers whic they held over their Heads. This obliged thoſ within to make Holes in the Walls, and throug them to ſhoot their Arrows at the Enemy to hinder them from attacking them. For which Way ſoever they came, the *Arbaleſta* annoyed them. Nevertheleſs the Foot of the Walls were without Defence, ſo that the Enemy lodging themſelves betwee the neareſt Holes, they bethought themſelves o

making

aking ſquare Towers with Holes on every Side: or they ſtood at the Head of the Walls, to hinr the Enemy from lodging between the Holes in e Wall. True it is, that they ſoon invented cerin Engines, which we call at this Day Battering ams, which were ſtrengthened at the Head with maſſy Point of Iron, and ſo puſhed againſt the alls of thoſe ſquare Towers, till they brought em to Ruin. After which they made Roundels, hich were looked upon as a ſtronger Sort of Forfication, till Power began to be known in *Eupe.* For we find in Hiſtory, that in the Year 380, under the Reign of *Wenceſlaus*, the Son *Charles* IV. a certain *Franciſcan* Monk, whoſe ame was *Berthold Schwarts*, of *Friburg* in *Briſgau*, ewed the firſt Uſe of Powder to the *Venetians*, en at War with the *Genoeſes*. After which they ade Cannon to batter Places; the furious Execuon of which, ranverſed like a Clap of Thunder oſe feeble Walls; which obliged them that were tacked with theſe aſtoniſhing Engines, to erect a od Rampart behind their Walls, and to make the me Walls much thicker than before.

This Manner of Fortification would have ſubted a long Time, had it not had one Defect; hich was, that thoſe Round Towers had one rt in the Form of a Triangle, which could not ſeen by thoſe within; and which the Enemy veted to batter, on purpoſe that he might dge himſelf ſecure from the Shot of the Beſieged, ho could not ſee him in that Part. To correct is Default, they filled that defective Part with od Earth, which being environed with a good all, formed alſo two Points which looked tord the Field, as now do the Faces of a Baſtion, and which covered that Part. The Enemy ſeein that, began to attack thoſe two Faces firſt of all So that the Beſieged found themſelves obliged t add Flanks to thoſe Faces, to plant Cannon upo them, and prevent the Enemy from doing ſo muc Miſchief to the Faces as before. And thus th Baſtions were invented, as we ſee them at this Da built upon the Angle of the Gorge.

Sect. 3. *Of the Parts of Fortification.*

THere are three Parts of it; that is to ſay *Ichnography*, *Orthography*, and *Scenography*.

Ichnography is what we call the Plane, or Repreſentation of the Length and Breadth of a Fortreſ of which the Parts are marked out either upon th Ground, or upon Paper.

Orthography is called the Profil, or the Repreſentation of a Fortreſs made and raiſed, ſo th a Man may ſee the Length, the Breadth, an Height of its Parts.

Scenography is the Perſpective of the Parts of Fortreſs.

Sect. 4. *Of the Diviſion of military Architecture.*

FOrtification is Regular or Irregular:

Regular is that where all the Sides, and a the Angles that compoſe it, are equal one to an ther.

Irregular is that where all the Sides and Angl are not all equal nor uniform one to another. An it is either durable or temporary.

Durable is that which is built to continue a lon Time.

Tempora

Temporary is that which is erected in caſe of Neceſſity for a little Time: And under this Signification are contained all ſort of Works erected for the ſeizing upon a Paſſage, or ſome Hill, or when they make Circumvallations, and Countervallations; that is to ſay, Redoubts, Trenches and Batteries.

CHAP. II.

Of the Parts of a Fortreſs, and its Angles.

THE *Courtain*, ſee Chap. 4. under C.

The Flank, ſee Chap. 4. under F.

The Face, ſee Chap. 4. under F.

The Face prolonged, is the reſt of the Flanking Line, after you have taken away the Face.

The Flank prolonged, is the prolonging of the Flank to the exterior Sides.

The Demi-Gorge, ſee Chap. 4. under D.

The Capital Line, ſee Chap. 4. under L.

The Line of Defence, is made high and razing, ſee Chap. 4. under L.

The Complement of the Courtain, ſee Ch. 4. under C.

The Diſtance of the Polygons, ſee Chap. 4. under D.

The half Diſtance of the Polygons, ſee Chap. 4. under D.

The interior Side of the Polygons, ſee Chap. 4. under C.

The exterior Side of the Polygons, ſee Chap. 4. under C.

The ſmall Diameter, ſee Chap. 4. under P.

The great Diameter, ſee Chap. 4. under G.

See the Plan repreſenting all theſe Parts.

Of the Angles.

THE *Angle of the Center*, or Angle of the Figure, is that which is made by drawing righ Lines from the Center to the two neareſt Angles o the Polygon.

The Angle of the Circumference is the mixed Angle which is made by the Arch, which is drawn from one Gorge to the other.

The Flanked Angle is the Angle compoſed of tw Faces.

The Flanking Angle is the Angle compoſed of th Line of Defence, and the Courtain.

The Angle of Complement of the Line of Defence i the Angle which is made of the two Complements where they interſect one another.

The Angle Form-Flank is the Angle which is compoſed of one Flank and one Demi-Gorge.

The Angle Form-Face is that which is compoſe by one Flank and one Face.

The Angle of the Moat is that which is made before the Courtain where it cuts itſelf.

The Re-entering Angle is that which retires inwar

The Saliant Angle is that which advances towar the Field.

See the Plate A.

CHAP. III.

Of the Terms of the Meaſures.

A *ROD* is the Length of twelve geometric Feet, and is made uſe of in *Germany* a *Holland*.

A Fathom is the Length of ſix geometrical Feet, of which they make uſe in *France*.

A geometrical Pace is the Diſtance of five geometrical Feet.

The ſimple Pace is the Diſtance of three geometrical Feet.

The Cubit is the Length of one Foot and a half.

The geometrical Foot is the Diſtance of twelve Thumbs Breadth.

A Thumb's Breadth is the Length of twelve Lines, of which the one is a Barley-Corn's Diſtance from the other.

A German League is the Space of 4000 geometrical Paces.

An Italian League is the Space of 1000 geometrical Paces.

A ſimple French League is the Space of 1000 geometrical Paces.

A common League is the Space of 2000 geometrical Paces.

A Furlong is the Space of 125 geometrical Paces, of which they make uſe in *Greece*.

A Paraſangue is the Diſtance of thirty Furlongs, or 3750 geometrical Paces, made uſe of in *Perſia*.

The ſimple Schœnus or Cord is the Diſtance of thirty Furlongs among the *Ægyptians*.

The compound Schœnus is the Diſtance of ſixty Furlongs in *Ægypt*.

⁂

CHAP. IV.

Of the Names and Terms made uſe of as well in attacking, as in the Defence of Places, alphabetically ſet down.

A.

WINGS, are the large Sides which terminate and bound to the Right and Left the exterior Works, as the Horn and Crown-work, *&c.*

Wings of Armies, are the Regiments poſted upon the right and left Hand, when the Army is drawn up in Battalia.

Anteſtature, is a ſmall Retrenchment made of Gabions, to poſſeſs the Remainder of the grand Attack.

Approaches, are all Sorts of Advantages, by the Aſſiſtance of which we advance toward a Place beſieged.

Arriere-Guard, is that Part of the Army whic marches after the main Battle, to hinder and ſto Deſerters.

Arſenal, is a Place appointed for the forming an Preſervation of every Thing that is neceſſary fo Defence and Aſſault.

Artillery, is all Sort of Fire-Arms.

Aſſault, is an Attack made upon a Fortreſs, t win it by main Force.

Attack, is an Effort made by the Beſiegers, t approach the Walls of a Fortreſs.

Falſe Attack, is an Effort to the ſame End, bu more remiſs, to oblige the Beſieged to divide thei Forces.

To attack in Flank, is to attack both Sides of th Baſtion.

Bacul

B.

Bacule, is a Gate that is made like a Pit-Fall, with a Counterpoiſe, before the *Corps de Gards* advanced near the Gates, and which is ſupported by two great Stakes; a Portcullis.

Banquette, a little Foot-Pace at the Bottom of the Parapet, upon which the Soldiers get up to fire into the Moat, or upon the Covert-way.

Barricadoes, are Trees cut with ſix Faces, croſſed with Battoons as long as a Half-Pike, bound about with Iron at the Feet, and ſet up in Paſſages or Breaches to keep back as well the Horſe as Foot.

Barriers, are great Stakes planted ten Feet one from another, about four or five Feet high, with their Tranſoms or overthwart Rafters, to ſtop thoſe that would enter with Violence; and where they cry to every Body that ſhew themſelves, *Whence come ye?*

Baſtion, is a Heap of Earth uſually raiſed upon the Angle of the Gorge, compoſed of two Flanks and two Faces.

Flat Baſtion, is that which is raiſed upon the Courtain, when it is too long to be defended by the Baſtions on each Side.

Battalion, are ſeveral Foot-Soldiers ranged in Battalia: It is compoſed of two Marches of Muſqueteers, and a Center of Pike-men.

Battery, is a Place raiſed, whereon to plant the great Guns, and play upon the Enemy.

Berme, is a little Space of four or five Feet, left at the Foot of the Rampart without, to prevent the Earth from falling into the Moat.

Blinds, are Pieces of Wood ſet a-croſs upon the Trenches to ſuſtain the Bavins or Hurdles laden with Earth, which are to cover the Trench.

Red Bullets, are Bullets made red-hot in a Forge, with which the Canon are charged to ſet Fire upon Houſes or Magazines.

Boyau, is a Moat bordered with a Parapet, which is drawn from one Trench to another for better Communication.

Breach, is the Ruin which the Canon or a Mine makes in a Fortification to take it by Aſſault.

Briſure, is a Line from four to five Fathom, which is allowed to the Courtain and Orillon to make the hollow Tower, or to cover the concealed Flank.

C.

A Bomb-Cheſt, is a Kind of a Wooden Cheſt wherein are put from three to ſix Bombs, which is placed under Ground, to blow it up in the Air, in caſe it be taken.

Camp Flying, is a ſmall Body of any Army which keeps the Field, to prevent the Incurſions of the Enemy, harraſs the Country, hinder Convoys, and to throw itſelf into any beſieged Place.

Caponiere, is a hollow Lodgment of about four or five Feet, bordered with a little Parapet of above two Feet high, to hold Planks laden with Earth; there are little Embraſures ſometimes made in them, which are called Murdreſſes. This Lodgment is wide enough to contain twenty or thirty Soldiers, and is uſually placed upon the Extremity of the Counterſcarp.

Carcaſſe, is an artificial Fire compoſed from three to four Granadoes, with ſeveral Barrels of Piſtolets charged, and wrapped up in Tow, dipped in oily Subſtances, with a pitched Cloth round about it: All which is put in a Kind of Lanthorn, which has a thin Plate of Iron at each End, held faſt by two Branches of Iron, which are croſſed by Circles of the ſame Matter; and in one of theſe thin Plates there is a Hole to fire the Carcaſs, which is afterwards forced into the Air like a Bomb.

Cartouche, is a Roll wherein the Charge of the Cannon is put, which, beſides the Powder, conſiſts of ſeveral Chain-Rings, Ends of Piſtols, Bullets, Heads of Cart-Nails, and other Iron Materials: And the Cannon concealed in the retired Flanks is uſually charged with ſuch Cartouches to make the more Havock.

Caſcans, are certain Wells, ſome more hollow than others, which are made in the Retrenchment of the Platform near the Wall, to give Air to a Mine.

Caſamatte, is a certain Vault made in a Part of the Flank which is next the Courtain, all of Maſons Work; it is made to fire upon the Enemy, and defend the Face of the oppoſite Baſtion and the Moat.

Cavalier, is a Maſs of Earth raiſed in a Fortreſs, to lodge the Cannon, to ſcour the Field, or oppoſe commanding Work.

Chandeliers, are Wooden Parapets covered with avins, filled with Earth about a Foot high, made uſe of in Approaches, Mines and Galleries, to cover the Workmen, and hinder the Beſieged from conſtraining them to quit their Labour.

Chauſes Trappes, or *Caltrops*, are Irons with four Spikes about four Inches long, ſo diſpoſed, that which Way ſoever they fall, one Point ſtill lies uppermoſt; they are made uſe of to throw into Moats and Breaches, to ſtop the haſty coming on of the Enemy.

Covert-Way, is a Walk round about the Moat towards the Country, having a Foot-pace and the Glacis for a Parapet.

The Chemin de Ronde, is a Walk between the Rampart and the Wall.

The Shirt or *Chemiſe*, is the Solidity of the Wall from the Talus to the Stone Row.

Chevaux, or *Frieſland Horſes*, ſo called, becauſe firſt made uſe of at *Groningen*, a City of *Frieſland*, are great Pieces of Wood with ſix Sides, driven through Piles or Stakes of Wood armed with Iron, to hinder the Horſe and Foot from going forward.

Circumvallation, is a Moat bordered with a Parapet, which flanks itſelf from Diſtance to Diſtance, ſunk about the Beſiegers Camp, as well to hinder the Relief of the Beſieged, as to ſtop Deſerters.

Clayes, are twigs interwoven together, having the Figure of a long ſquare; they are placed upon an Allodgment, and covered with Earth; and ſometimes they are laid upon marſhy Ground to conſolidate it.

Coffer, is a hollowed Depth from ſix to ſeven Feet, and broad from ſixteen to eighteen, all a-thwart a dry Moat: Upon the upper Part of this they place a Parapet, and a-croſs Pieces of Wood, covered with Clay loaden with Earth.

Commandment, is a Height of nine Feet which one Place has above another.

Complement of the Courtain, is the Remainder of the Courtain after you have taken away its Flank, to the Angle of the Gorge.

Complement of the Line of Defence, is the Remainder of the Line of Defence, after you have taken away the Angle of the Flank.

Counter-Approaches, are Works which the Beſieged make to hinder the Approaches of the Enemy.

Counterſcarp, is properly the declining of the Moat on that Side next the Country; although by this Term is underſtood, the Covert-Way with its Parapet.

Counter-Forts, are certain Pillars and Parts of the Walls, diſtant from fifteen to twenty Feet one from another, which advance themſelves as much as may be in the Ground, and join themſelves to the Height of the Cordon by Vaults, to ſuſtain the Chemin de Rondes, and Part of the Rampart, to fortify the Wall, and ſtrengthen the Ground.

Counter-Guards, are triangular Pieces, in Form of a large Parapet, which raiſe themſelves above the Moat before the Faces and the Point of the Baſtion to preſerve them.

Countermine, is a ſubterraneal Way which the Beſieged make in ſearch of the Enemy's Mine, to make away the Powder, and fruſtrate the Effect of it, though fired by the Aſſailant.

Countervallation, is a Moat guarded with a Parapet, which the Beſiegers make to ſecure themſelves from the Sallies of the Garriſon.

Corbeills, are a Sort of Gabions filled with Earth placed upon the Parapet to fire upon the Enemy, without being ſeen by them.

Cordon, is a Row of Stones made round, which is placed where the Wall ends, and the Parapet begins; and it runs round about the Place.

Coridor, is the Covert-Way above the Counterſcarp, round about the Place, between the Moat and the Paliſadoes.

Cornes or *Horns*, are Out-works which advance toward the Field, and carry in the Fore-part two half Baſtions in the Form of Horns, which they preſent to the Enemy.

Crowning, is a Work drawn beyond the Horns to keep the Enemy at a Diſtance.

Courtain, is the longeſt ſtreight Line that runs about the Rampart drawn from one Flank to the other, and bordered with a good Parapet five Feet high, behind which the Soldiers place themſelves to fire upon the Covert-Way, and into the Moat.

Cuvete, a little Moat about four Fathom broad, which is uſually ſunk in the Middle of a great dry Moat, till you meet with Water. It is good to prevent the Beſiegers Mining.

D.

Defenſes, are all Sorts of Works that flank one another, and which the Enemy deſires to ruin, before he ſtrives to paſs the Moat.

Defile, is a ſtreight narrow Paſſage, through which there is no marching but in File.

Dehors, are all Sorts of ſeparate Out-works, as Ravelins, Half-Moons, Hornworks, Crownworks, Counterguards, Tenailles, *&c.* the better to ſecure the main Place.

Demi-diſtance of Polygons, is the Diſtance between the exterior Polygons and the Flanks.

Demi-Gorge, is a Line drawn from the Flank to the Angle of the Polygon.

Demi-lune, is a ſmall flanked Baſtion, placed before the Point of a Baſtion, when it is too weak; ſometimes this Work is placed before the Courtain, when the Moat is a little wider than it ought to be.

Deſcent into the Moat, is a deep digging into the Earth of the Covert-Way, in Form of a Trench, of which the upper Part is covered againſt artificial Fires, to ſecure the Deſcent into the Moat.

Diſtance of Polygons, is the Line compoſed from the Flank and its Prolongation, to the exterior Polygon.

Donjon, is a Place of Retreat, to capitulate with more Advantage in caſe of Neceſſity.

E.

Embraſure, the Hole through which the great Guns are diſcharged.

Embuſcade, the Place where the Soldiers hide themſelves to ſurprize the Enemy.

Enceinte, the Circumference of a Place, ſometimes lined, and compoſed of Baſtions and Courtains, ſometimes not.

Eſplanade, is the Place void of Houſes, between the Citadel and the Town.

F.

Face, is the moſt advanced Part of the Baſtion toward the Field, and is the firſt attacked.

Faſcins, are Bavins of ſmall Wood, two Feet broad, and four long, bound about at the Ends and Middle, thrown into Moats where there is much Water, to facilitate the Paſſage over to the Wall.

Fals Braye, is a ſmall Rampart four Fathom wide, bordered with a Parapet, and a Banquet, running round about the Body of the Place. It is made uſe of to fire upon the Enemy, when he is already ſo far advanced, that you cannot force him back from off the Parapet of the Body of the Place; or elſe, to receive the Ruins which the Cannon make in the Body of the Place.

Flank, is the Part which joins the Courtain to the Face of the Baſtion, from which the Face of the next Baſtion requires its Defence.

Flank Covert, is that, the exterior Part of which advances to ſecure the innermoſt; which advanced Part, if it be rounded, is called an *Orillon*.

Flank Fichant, is that which plays, and fixes its Bullets in a direct Line in the Face of the adjoining Baſtion.

Flank Razant, is that, from the Conjunction of which with the Courtain, the Shot razes the Face of the next Baſtion; which happens when the Face cannot be diſcovered but from the Flank alone.

To Flank a Place, is to play upon a Place in ſuch a Manner, that there ſhall be no Part of it but what is defended; and from which you may play upon the Enemy both in Front and Rear, and ſo oblige him to retire.

Forts of the Field, or *Fortins*, are all Fortreſſes, whoſe flanked Angles are diſtant one from another 120 Fathom. They are only for a Time to guard ſome Paſſage, or dangerous Place; or elſe they are uſed in Circumvallation.

Foudage, is a ſmall Mine made under the Ground, which the Enemy would blow up. It is furniſhed with ſome Sacks of Powder, to which the Sawedge is fixed, which anſwers to another Poſt, to the end it may be fired without Danger.

Fraiſes, are Pieces of Wood from ſeven to eight Feet long, driven in almoſt half Way into the Earth of the Rampart without Side, and a little below the Parapet, they preſent their Points ſomewhat ſloping toward the Field; and are made uſe of to prevent Deſerters and Surprizes.

G.

Gabions, are Baſkets equally wide at Top and Bottom, about four Feet in Diameter; they are filled with Earth, and uſually placed upon Batteries and Parapets that have ſuffered very much, and before other Places, to ſecure them from the Enemy's Shot.

Gallery, is a covered Walk, either of Earth or Turf. The Sides of it are made with Planks and Pillars; and they are made uſe of in the Moat already filled with Faggots and Bavins, to the end the Miner may approach ſafe to the Baſtion.

Glacis, is the Parapet of the Covert-way which loſes itſelf inſenſibly in the Field. The largeſt are the beſt.

Gorge, is the Entrance of the Platform of the Baſtions and other Works: It never ought to have a Parapet, for fear the Enemy being Maſter of it, he ſhould ſecure himſelf thereby from the Shot of the Garriſon.

Granado, a little hollow Globe filled with Powder, to which there anſwers a little Fuſee of Powder, to ſet them on Fire; they are uſed to fire cloſe and narrow Places; or elſe to diſorder the Ranks of the Soldiers.

Grand Demi-Diameter, is the Line compoſed o the Capital, and the ſmall Demi-Diameter of th *Polygon.*

Grazons, are Pieces of freſh Earth, covered wit Graſs, about a Foot long, and half a Foot thick cut in the Form of a Wedge to line the Parapet and the Traverſes of the Galleries.

H.

Heriſſon, a Beam, with a great Quantity of Nail having their Points outward; it is ſupported by a Pivot upon which it turns, to ſtop up any Paſſag inſtead of a Barrier.

Herſe, is a Lattice, or Portcullis, of great Pieces of ſharp-pointed Wood at the lower End, ſuſtained by a Cord faſtened to a *Moulinet*, which is cut i caſe of Surprize, to the End the Herſe may fall, and ſtop up the Paſſage of a Gate, or other Entrance of a Fortreſs.

Horſe-Shoe, is a Work ſomewhat round, ſomewhat oval, bordered with a Parapet: It is made to ſecure a Gate, or to relieve an over-tedious Defence.

L.

Line Capital, is a Line drawn from the Angle of the Gorge, to the Angle of the Baſtion.

Line Cogrital, is the Line drawn from the Angle of the Center to the Angle of the Baſtion.

Line of Defence, is that which is repreſented by the Diſcharge of the ſmall Shot, which uncovers the Face of one Baſtion by razing it.

Line of Defence Fichant, is the Line drawn from the common Point to the Courtain, and from the Flank to the flanked Angle of the Baſtion.

Line of Defence Razant, is the Line drawn from he capital Line of a Baſtion, to that Part of the Courtain where the Defence begins, to diſcover the ace of the ſame Baſtion.

Line of Communication, are the Lines that run rom one Work to another, to ſtop the Fury of the Enemy.

Lines within-ſide, are the Moats toward the Place o hinder Sallies.

Lines without-ſide, are the Moats toward the ield to hinder Relief.

Lodgment of an Attack, is a Work caſt up in a langerous Poſt, to ſecure themſelves againſt the Enemy's Fire: This Lodgment is made of all the Materials that are capable to make Reſiſtance.

To line, is nothing elſe but to environ a Rampart, Parapet or Moat, with a good Wall or good Turf.

M.

Madrier, is a thick Plank, ſufficient to cover the Mouth of a Petard, and which is applied with the Petard againſt the Places they would break: This Term is alſo applied to ſeveral flat Beams which are put at the Bottom of a Moat to ſupport the Wall.

Mantellet, is one or ſeveral Planks joined together, and covered with Tin, carried upon two Wheels, which the Pioneers in a Siege drive before them, to ſecure themſelves againſt the ſmall Shot.

Merlon, is that Part of the Parapet which is between the two Embraſures.

Mortier, is a Piece of great Cannon very ſhort, which is charged with Bombs, Carcaſſes, or Stones; and is mounted upon a Carriage, the Wheels of which are very low.

Moulinet, is a Croſs of Wood, which turns horizontally upon a wooden Stake, which ſtands at the Side of the *Barrier*, between the Bars of which the Footmen paſs.

Moyenau, a Sort of ſmall flat Baſtions, placed in the Middle of an over long Courtain, of which the Baſtions that are at the Extremities, are not well defended from the ſmall Shot by reaſon of their Diſtance. This Work is proper for the placing in it a Body of Muſketteers, to fire from all Sides.

N.

Nailing of Cannon, the driving of a Nail by Force into the Touch-hole of a great Gun.

O.

Orgues, are thick and long Pieces of Wood, hung up over a Gate, every one by a Cord, which anſwers to the *Moulinet*, that is to be cut in caſe of a Surprize; and they are to be preferred before *Herſes.*

Orillon, is a ſmall Rounding, which joining with the hollow Tower, at the End of the Face of the Baſtion, covers one Part of the Flank.

P.

Paliſadoes, are wooden Stakes from five to ſeven Feet high, armed with two or three Iron Points, which are fixed before Fortreſſes, Courtains, Ramparts, and Glaces: Some there are which are not armed with Iron.

Parapet, is an Elevation of Earth upon the Rampart, behind which the Soldiers ſtand, and where the Canon is planted for the Defence of the Place.

Park, is a certain Place made choice of in the Camp, out of Cannon-ſhot of the Place beſieged, o plant the Artillery, and to keep the artificial Fires, Powder, and warlike Ammunition: which s only guarded by Pike-men.

Petard, is a hollow Engine made of Metal, almoſt in the Shape of a Cap, from ſeven to eight Inches deep, and five Diameter in the Muzzle. It s charged with Powder beaten as ſmall as may be, nd then fixed to the *Madrier*.

Petty Demi-Diameter, is the Circumference drawn rom the Center through the Gorges.

Place of Arms, is a Piece of Ground ſufficient to raw up the Men to be ſent from thence as Occa-ion requires.

Place of Arms without, is a Place allowed to the Covert-ways where they make obtuſe Angles, hereon to plant ſome Pieces of Cannon, or Fal-ons, to force thoſe that advance in their Ap-roaches to retire.

Place of Arms particular, is a Place near every Baſtion, whence the Soldiers ſent from the grand Place to the Quarters aſſigned them, relieve thoſe hat are either upon the Guard, or in Fight.

Place irregular, is a Place whoſe Angles and ides are unequal.

Place regular, whoſe Angles and Sides are every here equal.

Plane, the Repreſentation of a Work in its Height and Breadth.

Platform, is the whole Piece of Fortification aiſed in a re-entering Angle.

Polygon exterior, is the Diſtance of one Point of Baſtion from the Point of the other.

Pont de Jonc, is a Bridge made of great Bundles of Bullruſhes, that grow in the Marſhes, which are afterwards bound together, upon which they lay Planks, and then lay them in muddy and marſhy Places to ſecure their footing.

Pont Flottant, or Floating Bridge, is a Bridge made in Form of a Redoubt compoſed of two Boats covered with Planks: They ought to be ſo ſolidly framed, as to bear Horſe and Cannon.

Poſtern, is a falſe Door, often made at the Bottom of the Curtain, or near the Orillon, for private Sallies.

Profil, the Draught of a Work, with all its Lengths, Breadths and Heights.

Q.

Quarter of a Siege, is the Incampment upon one of the moſt principal and important Paſſages round about the Place beſieged, to prevent Relief, and Convoys.

R.

Ravelin, is a ſmall triangular Work without Flanks, and having no more than its two Faces: It is generally raiſed before the Curtains, where the Moat makes a ſaliant Angle.

Redans, Works made in Form of the Teeth of a Saw in re-entring and ſaliant Angles, to the End that one Part may defend another: They are uſually placed upon the Entrances into Rivers.

Redoubt, is a ſmall ſquare Foot, having no Defence but in Front. It is uſually deſigned to maintain the Trench, for Circumvallations and Countervallations; and in watry Places they are often made of Maſons Work for the Security of the Neighbourhood.

Reduit, an advantageous Piece of Ground entrenched from the reſt of the Place, to retire to in caſe of Surprize.

Rampart, is the raiſing of the Earth which runs about a Place, compoſed of Baſtions and Courtains, wherein to put the Soldiers, and plant the Cannon for the Defence of the Place.

Retirade, an Intrenchment formed by two Parapets making a re-entering Angle, which is made in a Work reſolved to be diſputed Inch by Inch. Sometimes it has a Moat.

Retrenchment, is a Work made of Part of a Rampart, when the Enemy is ſo far advanced, that he is no longer to be reſiſted or beaten from the old Rampart; and to the End that he may not make any new oppoſition; it is bordered with a good Parapet, and ſometimes with Gabions and Bavins laden with Earth.

Rideau, is a ſmall Elevation of Earth in the plain Field, which extends itſelf in Length; very proper for thoſe that would beſiege a Place at a near Diſtance, and to ſecure thoſe that would approach to the Foot of the Place.

Rondel, is a round Tower ſometimes raiſed at the Foot of the Baſtions.

S.

Sack of Earth, a Sack of coarſe Cloth to contain a Foot, or a Foot and a half; ſerviceable upon ſeveral Occaſions, but eſpecially for the making Retrenchments in haſte.

The Saignor, a Moat, to empty the Water by ſubterraneal Conveyances, to paſs it the more eaſily, after you have caſt Hurdles upon the Mud that remains.

Sappe, is the deep digging into the Earth of the Covert-way and Glacis in the Form of a Trench. The Earth which is thence digged out, ſerves for Security on the Right and Left, and covers you above againſt the Fire-works by the Help of the Hurdles laden with Earth.

A Sarraſin, is no more than a Herſe.

Saucidge, is a Piece of long Cloth, of which they ſow the Sides all along in Form of a Gut, which they dip in Pitch, and fill with Powder: The Largeneſs of it ought to be ſo much as to contain a Tennis Ball; and then they put one End of it to the Place where the Mine is, or a Foudage, or Cheſt of Bombs, and the other End anſwers to the Place where the Engineer ſtands that ſets it on fire.

Saucidges, are Faggots made of great Boughs, bound in the Middle and both Ends; whoſe uſe is the ſame with that of Bavins.

Shouldring, is nothing but Orillon.

Scalade, the mounting of the Wall with Ladders.

Scarp, the *Talas*.

Star, a Work with ſeveral Faces, compoſed of Parts, of which the one flanks the other.

Sillon or *Envelop*, a little Rampart covered with its Parapet, raiſed in a very large Moat, the Draught of which forms re-entering and ſaliant Angles, to the end that the Parts may reciprocally flank each other.

T.

Talut, is that Declivity or Inclination which is allowed to Works whether of Earth or Maſonry, the better to ſupport them; and the worſe the Earth is, the more ſloping they ought to be.

Tenaille, is a Fortification that has in Front a re-entring Angle, when it has no Flanks; and this is called a ſimple Tenaille: But if it have Flanks, then it is called a flanked Tenaille.

Terre-plain, is that Part of the Rampart which is equally level for the Recoil of the Cannon.

Towre Hollow, is a Rounding made of the Remainder of the two Briſures to join the Courtain to the Orillon; where the ſmall Shot are placed, that they may not be ſo much expoſed to the View of the Enemy.

Trenches, are Moats which the Beſiegers make to approach the more ſecurely to the Place attacked. The Depth of it ought to be from ſix to ſeven Feet; the Breadth from eight to ten. They are ſo to be carried on, as not to be in View of the Enemy.

Traverſe, is a little Moat bordered with a Parapet to the Right and Left, which the Beſieger makes quite a-thwart the Moat of the Place, to paſs ſecure from Flank Shot, and bring his Miners to the Baſtion. This Traverſe is covered with Hurdles loaden with Earth, for Security from the Fire-works. The only Difference between this Work and the Coffer, is this, that the one is made by the Beſieger, and the other by the Beſieged.

V.

Vedette, a Centinel on Horſeback.

BOOK II.

CHAP. I.

Of the Maxims of Fortification.

SINCE it is impoſſible to build a Fortreſs, without having conſidered before-hand what Reaſons there are to induce an Engineer to do it after ſuch a Manner, that there is no great Matter to be objected againſt it; there are ſome certain Maxims eſtabliſhed, according to which, when a Fortification is raiſed, there can be but little ſaid againſt its Advantages to thoſe that are within; as you may eaſily examine it yourſelf by the following Obſervations.

I. All the Parts which are to encloſe a Space of Ground, ought to be flanked; that is to ſay, viewed on every Side, that ſo there may be no Shelter about the Place where the Enemy may lodge himſelf, but what may be diſcovered by thoſe within, not only from the Front, but from the Sides, and even from behind, if it be poſſible.

II. Whatſoever encloſes a durable Fortification, muſt be either Flank, Face, or Courtain, and built after ſuch a Manner, that the firſt Diſcharges of the Cannon may not be able to pierce its Thickneſs.

III. Regular Fortification is much to be preferred before that which is irregular.

IV. It is impoſſible to fortify a Triangle after the regular Way, becauſe the Angle of the Gorge is always leſs than ninety Degrees.

V. The acuter the Angle of the Center is, the Place is by ſo much the ſtronger, and conſequently better, becauſe it will have more Sides.

VI. The Angle of the Baſtion muſt never be greater than 100 Degrees, nor leſs than ſixty; for being bigger, the Face cannot be defended as it ought to be; and being leſs, it is not able to reſiſt the Injury of the Weather, or the Efforts of the Mines and Cannon. See Chap. 1. Sect. 4. of Book IV.

VII. The greateſt Angles are beſt to fortify.

VIII. The Angle of the Courtain ought never to be leſs than ninety Degrees, nor greater than 110; becauſe, if it be larger, it is too much ſubject to the View of the Enemy. See Chap. 1. Sect. 5. of Book IV.

IX. The great Demi-Gorges are to be preferred before the ſmall ones, as well becauſe there is more Space to retrench in, as becauſe one may make retiring Flanks, which adds very much to the Strength of the Place.

X. Great Flanks are beſt.

XI. The Face ought to be never leſs than the half of the Courtain, if it be not in an irregular Fortification.

XII. The Faces of the Baſtion ought to be defended by the ſmall Shot of the oppoſite Flanks.

XIII. The ſhorteſt Faces are beſt, becauſe they are not ſo ſubject to be attacked, as when they come out a great Way in the Country. See Chap. 3. of Book IV.

XIV. The Courtain ought never to be ſhorter than ſixty Fathoms, which is 360 Feet *Engliſh*; nor longer than 100; if it be not in an irregular Fortification.

XV. The Line of Defence muſt not be of greater Length than 120 or 125 Fathoms, becauſe a Muſquet can carry no farther to do Execution. *Holdman* contradicts this Axiom, when he ſays, that it may be 150 Fathoms; and likewiſe *George Paſcha*, who believes it may be 136 Fathoms long.

XVI. The Talut or Level ought by no means to be forced or ſtreightened, but ought to have ſloap enough, that the Ground or Earth may ſettle of itſelf.

XVII. Large and deep Trenches are to be preferred before thoſe that are narrow and hollow, or large and leſs deep, becauſe the Enemy will find more Difficulty to get over the firſt Sort. See Chap. 10. of Book I.

XVIII. Dry Trenches are to be eſteemed before thoſe that are full of Water, eſpecially in great Places, where Sallies, Retreats, and Succours, are neceſſary.

XIX. Trenches full of Water that cannot eaſily be drained, ought to be preferred before thoſe that are dry in ſmall Fortreſſes, where Sallies, Retreats, and Succours, are not ſo neceſſary.

XX. The Out-works ought always to be lower than the Body of the Place; and thoſe that are at the greateſt Diſtance ought to be the loweſt.

CHAP. II.

Of the Situation of Places.

AS it is very rarely permitted to make choice of that Space of Ground which is to be fortified; but on the contrary, the Place is almoſt always determined, whether we deſign to repair an old Fortification, or ſurround any Town with Baſtions, and other kind of Works; or whether we are to make ourſelves Maſters of the Paſſage of a River, or any ſtrait Place, or an Eminence, that is of Advantage to command the flat Country, or an Iſland in a River, or of one or more Jettings out of Land into the Sea for the making a Port; and laſtly, for ſeveral other Uſes, the Recital whereof would be too tedious: It is neceſſary upon theſe Accounts to underſtand, what Kind of Situations are beſt for the erecting a ſtrong Hold, and to know the Opinions of others concerning this Matter.

I. *What are the Advantages of a Fortreſs ſituated upon a Mountain.*

1. This Fortification is not eaſily ruined by Mines.

2. The Enemy will be at a great deal of Difficulty to bring their Machines to batter down this Fortification.

3. Thoſe of the Place may diſcover the Enemy at a great Diſtance, and ſo hinder them from making their Approaches nearer.

4. The Horſe or Batteries of the Enemy, which are planted either on plain or riſing Ground, can no Ways do any Damage to this Fortification, it being always lower.

5. Upon an Eminence, the Air is always more healthy than in Vallies or lower Places.

6. The Enemy will but very rarely be able to take ſuch a Place by Aſſault.

What are the Diſadvantages of a Fortreſs built upon a Rock.

1. They commonly want Water in ſuch a Place.

2. It is difficult to bring thither Materials, Proviſions, and other Ammunition.

3. Theſe Fortifications are, for the moſt part, not very durable, having only a ſandy or gravelly Earth for Foundation.

4. Places ſo ſituated, are not to be ſuccoured but with great Difficulty.

5. Such a Place cannot be well defended, beauſe what is done by the Cannon from Top to ottom, is but of little Conſequence.

6. Sallies are there very dangerous, eſpecially if hey be at any Diſtance from the Counterſcarps.

7. Theſe Fortifications are almoſt always irreular.

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It is to be obſerved, That theſe kind of Situaions are good for Citadels, Caſtles, and other ſmall Forts, in order to command the Country therebouts.

II. *The Advantages of a marſhy or fenny Situation.*

1. The Enemy cannot come near it without Danger of being loſt.
2. This Fortification is not eaſily blown up.
3. Theſe Places may be fortified for little Charge.
4. They have there no need of a great Garriſon.

The Diſadvantages of a marſhy Situation.

1. It is almoſt impoſſible to relieve it.
2. It muſt be ſtrengthened with Piles driven in.
3. Sallies thence are commonly unſucceſsful.
4. The Air is there always unhealthy, which is he Occaſion of frequent Diſtempers, becauſe the Water there is always corrupted.
5. Theſe Places may be attacked without any great Loſs of Men, provided they ſtay till the Froſts.

III. *The Advantages of a Place encompaſſed round with Water.*

1. It cannot be undermined.

2. There is no Occaſion for any great Works.

3. The Enemy cannot always diſcharge thei Cannon with any Certainty, becauſe the Wate abates much of their Force.

4. The Beſieged may very eaſily ſet Fire to th Enemy's Shipping.

5. The Naval Army is too much expoſed to th View of the Artillery of the Place.

The Diſadvantages of a Place ſurrounded with Wate

1. The Enemy may eaſily ſtop their Proviſion and hinder their Succours.

2. Boats alone are ſufficient to attack ſuch Place, and ſo there is no Occaſion for Horſe.

3. Theſe Places are more ſubject to Diſeaſes tha others.

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We may affirm, that theſe Places that are encompaſſed all around with Water, which cannot b quite drained, or at leaſt with great Difficulty, ar the beſt notwithſtanding, becauſe they are, as i were, fortified by Nature.

IV. *The Advantages of Places ſituated upon an ope plain Ground.*

1. There is great Plenty of good Earth.

2. They are never there in want of Water.

3. Almoſt all theſe Places are commonly regular

4. They have there Earth enough to make Retrenchments, in caſe the Enemy make their Attack with great Fury.

5. The Enemy had need to have two or three Armies, if they would intercept the Proviſion and Ammunition coming to thoſe of the Place from all Parts.

The Diſadvantages of Places erected upon a plain Ground.

1. The good Soil that there is about ſuch a Place, ſerves only for the Enemy to make Retrenchments, Batteries, Approaches, Redoubts, and other Works, from thence they may do great Damage to the Beſieged.
2. The Enemy may form their Camp, as thoſe of the Place did their Fortification; that is to ſay, they may give it a regular Figure, and encompaſs it with a good Trench, and a good Rampart.
3. The Ground is very good to make Mines under ſuch a Place.
4. The Enemy may ſeize all the Fruits growing about theſe Places.

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Theſe Places however are beſt, becauſe thoſe of the Place will take double the Advantage that the Enemy can have.

V. The Side of a Mountain is a very ill Place to fortify, and it muſt be avoided as much as may be, becauſe the Top of the Mountain almoſt always commands the Place within.

VI. The Valley is no good Place to fortify, becauſe the Enemy may diſcover them from the Top of the Mountain.

VII. *The*

VII. *The Advantages of Places ſituated on the Si of any great River.*

1. You may bring thither by Water, whatſoev is neceſſary for Building, and for the Soldiers.

2. You may fortify your Circumference after t regular Manner, or at leaſt very near it: The Si towards the Water is fortified with ſmall Charge

3. It may be eaſily relieved.

4. Earth is there very plentiful for repairing t Works, and for making Retrenchments.

5. You may there make Sluices to put all t Country thereabouts under Water.

6. They never want there any Water.

7. The Enemy muſt have a great many Troo to lay Siege to ſuch a Place, by reaſon of the D ſtance of the Quarters.

8. If it be attacked only by Land, nothing hi ders but that the Beſieged may paſs the River Pleaſure, and receive Succours by Boats.

9. If it be attacked both by Land and by Wate there muſt be two great Armies, which will be ve chargeable.

The Diſadvantages of Places ſituated on the Sides of great River.

1. The River ſerves the Enemy for tranſporti whatſoever is neceſſary for a Siege.

2. The Enemy may caſt up great Heaps Earth to command the Place.

3. The Enemy may eaſily ſhelter themſelv from the Firing of the Beſieged, having gre Plenty of Earth.

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It is not to be denied, but that theſe Places are be preferred before any of thoſe that we have ow mentioned, in caſe they are Maſters of the aſs, by which the Proviſion and Ammunition is come in.

CHAP. III.

Of the Quality of the Earth.

WHEN you have once made choice of a Place for the erecting a Fortreſs, before ou engage yourſelf in ſo expenſive an Undertak-g, you muſt examine the Quality of the Earth, d conſider whether it be good or bad: For there e very advantageous Situations, the Earth whereof good for nothing; and on the contrary, there are Situations that have a very good Soil, but they e ſubject to be commanded after ſuch a Rate, that would be great Folly to ſettle there: As may be vident by the following Obſervations.

Sect. 1. Mountains commonly have a ſtony round, which is the worſt of all, as well becauſe will not ſtick together, as becauſe the Parapets ade thereof are good for nothing: But if you e compelled to fortify in ſuch a Place, you muſt ake choice of the beſt Veins of Earth to make e Parapet, and cauſe it to be brought from elſehere. It is true, this Sort of Earth is of ſome Advantage,

Advantage; in that the Beſiegers will find it difficult to cover themſelves in their Approaches for want of good Earth.

Sect. 2. Gravelly or ſandy Earth is likewiſe very bad, by reaſon that it wants a binding Quality, being always apt to tumble down; when you are forced to make uſe of this, you muſt mix ſome good Earth therewith, or ſome old Dung, and the Ramparts muſt be well lined with Stones or Bricks, and the Parapets with Turfs.

Sect. 3. Marſhy Ground is better than the two former Sorts, although generally it is not very good, becauſe when it comes to dry, being raiſed into Ramparts and Parapets, it is ſubject to fall to Pieces; beſides, it is difficult to find Earth enough about a marſhy Place for raiſing of Ramparts, Parapets, and Glacis's, of a reaſonable Height; and moreover, the Foundation of theſe Works muſt be always ſtrengthened with Piles. But if there be a Neceſſity of raiſing Fortifications in theſe Places, it muſt be during the Heats, that ſo the Earth may have the greater Conſiſtence.

Sect. 4. The beſt kind of Earth for fortifying, is that which they call fat or fertile Ground, becauſe it is pliable; and you are not obliged to ſtrengthen the Foundation with Piles, nor to line the Ramparts, unleſs you will.

C H A P.

C H A P. IV.

Of Proviſion, and other Neceſſaries.

SEEING a Place cannot be able to endure a long Siege, if it has not wherewithal to make Reſiſtance, therefore there muſt be Proviſion made of whatſoever is neceſſary for a Soldier; under which Head is to be underſtood, Money to pay the Troops, Meal, Corn, Hay, Wine, Beer, Brandy, Butter, Salt, Wood, Powder, Lead, Match, Bullets, Cannon or great Guns, Muſquets, Pikes, Sulphur, Pitch, Brimſtone, Paliſadoes, *Chevaux de Friſe*, Hand-Mills, Horſe-Mills, and Wind-Mills, that ſo, if the Enemy ſhould cut off the Water, they might not be without ſomething to grind their Corn. A good Commander will take Care of all this. An able Phyſician, Chirurgeon, and Apothecary, are there likewiſe very neceſſary. To theſe there might be added, ſome other Things requiſite, in order to keep the Soldiers in good Heart.

BOOK III.

CHAP. I.

Sect. 1. *How to inſcribe any Polygon within a Circle given.*

THIS Problem is commonly treated o in *Geometry*; nevertheleſs, becauſe it i impoſſible to work on a regular Fortification on Paper, without knowing before-hand how to inſcribe regular Figures in a Circle given or taken at Pleaſure, we ſhall at preſent diſcourſe ſomething thereof.

1. Divide the Diameter of your Circle given, AB, into as many equal Parts as you would giv Sides to your Figure: For Example, into five.

2. Draw the Diameter A B, and make wit this Diſtance of Points A B, two Arches to interſect in C.

3. Draw from the Point C, through the ſecond Part which is marked by the Point E, of the ſaid Diameter, a right Line, till it touch the Circumference alſo below the Diameter in H.

4. This Diſtance from the Interſection to the firſt Point A, of the Diameter, will be always on Side of the Polygon demanded.

See the Plate B, Fig. 2.

Sect. 2. *How to make a Scale.*

As every Thing is to be done by a Scale, you muſt know likewiſe the Manner how it is made; which is as follows:

1. Divide a Line into ten equal Parts, and one of theſe, to ſhew the Feet, into ten others; ſo one of theſe laſt ten will make the hundredth Part of your Line; that is to ſay, one Fathom of your Scale.

2. To make the Scale well, you muſt divide alſo one Fathom into ſix other equal Parts, to ſhew the Feet; for a Fathom is ſix geometrical Feet, as have been already ſaid. And by this Manner you will have a perfect Scale, for to know all the Breadths, Lengths and Heights.

3. When you would make any Thing that ſhould be very exact, you muſt likewiſe take a Foot, and divide it into twelve other equal Parts, and ſo you will have the Inches; for a Foot contains twelve Inches.

CHAP. II.

How to deſign a Square.

IN *France* there are three Sorts of Fortifications, the large, the middle-ſized, and the ſmall; but at preſent they never make uſe but of the middle-ſized: Nevertheleſs we will firſt ſhew the Difference, before we ſpeak of the middle-ſized.

The Square.

The large Manner.	*Fathoms*	*Feet*
1. The Semi-Diameter	141	00
2. The Side or exterior Polygon	200	00
3. The Perpendicular	27	00
4. The Face	60	00
5. For the Complement of the Line of Defence take	38	00
6. The Flank	22	00
7. The Courtain	73	04
8. The Line of Defence	141	04

The middle-ſized.	*Fathoms*	*Feet*
1. The Semi-Diameter	127	02
2. The exterior Side	180	00
3. The Perpendicular	22	00
4. The Face	55	00
5. For the Complement of the Line of Defence take	33	00
6. The Flank	18	01
7. The Courtain	64	04
8. The Line of Defence	126	00

The ſmall.	*Fathoms*	*Feet*
1. The Semi-Diameter	113	01
2. The exterior Side	160	00
3. The Perpendicular	21	00
4. The Face	45	00
5. For the Complement of the Line of Defence take	33	00
6. The Flank	18	04
7. The Courtain	64	00
8. The Line of Defence	115	04

The

The Explanation of the middle-ſized Table.

Having ſeen the Difference between theſe three Manners, we ſhall only ſpeak of the middle-ſized, as being the moſt in uſe at this Day; and to begin, we will examine the ſaid middle-ſized Table.

1. Take 127 Fathoms, and two Feet between the Points of the Compaſs, and make a Circle.

2. Take 180 Fathoms, and divide them with the Circle into four equal Parts: When they are joined the one to the other, they are called exterior Sides or Polygons, as A, B, C, D.

3. Divide one of theſe four Sides into two equal Parts with ninety Fathoms, as E, F, G, H.

4. Draw from the Points, E, F, G, H, ſtreight Lines toward the Center, which are called Perpendiculars; to which muſt be allowed twenty-two Fathoms in Length, as I, L, M, N.

5. Set the Rule to the capital Points, A, B, C, D, and draw ſtreight Lines through the End of the Perpendiculars, I, L, M, N, at Pleaſure.

6. Take fifty-five Fathoms, and place them upon the Lines drawn from the capital Points, to mark out the Length of the Faces, as a, b, c, d, e, f, g.

7. Take thirty-five Fathoms, and put them from the Point where the Perpendicular ends, *viz.* from the Point I, L, M, N, upon the Lines that have gone beyond the ſaid Points, to mark out the Length that is to be taken for the Complement of the Line of Defence, as J O, J P, L Q, L R, M S, M T, N V, N X.

8. Draw the End of the Faces and theſe Points O P Q R S T V X, which terminate the Complement of the Defence, and you will have the Flanks.

9. Then join together the Feet of the Flanks and you will have the Courtains.

To make the Orillon.

Monſieur *de Vauban* does not leave his Flanks, Monſieur *Pagan* has done, or as the *Dutch* an *Germans* do at this Day; but he conceals one Par the better to cover the Cannon by means of the Orillon: And for that Reaſon we will ſhew you hi Manner of raiſing it, which is not very difficult.

1. Divide the Flank into three equal Parts.

2. Divide the firſt of the three into two oth equal Parts, to join from this Middle, the two Extremities of the firſt Part, on the Side of the Moat and this little Rounding makes the Orillon.

To make the hollow Tower or Plank retired.

As you have ſeen the reforming of the firſt of th three Parts, placed upon the Flank, now you ſha ſee another of the two remaining Parts, the Forn of which you muſt henceforward call the *Hollo Tower*, the Conſtruction of which is thus:

1. Draw from the capital Points of the Baſtion a ſmall ſtreight Line withinſide of the Baſtio through the End of the Orillon.

2. Put five Fathoms upon this Line which yo have drawn, as alſo upon that which is almoſt parallel to the lower Part of the Courtain. This called the *Briſure*.

3. Take the Extremities of the Briſure with th Compaſs, and with that Diſtance draw two Arche which interſect one another toward the Moat, i Figure 8.

4. P

4. Put the Compaſs upon that Interſection, and join the ſaid Extremities of the Briſure together by a crooked Line; and thus you will have the Figure which is made at this Day in *France* inſtead of the Flanks, as alſo the Deſign of the entire Square. See under B, Fig. 3.

CHAP. III.

Of the Structure of the Body of the Place of the Square.

WE are now to ſee what Largeneſs or Breadth is to be allowed to the Ramparts, Parapets, Moats, Covert-Ways, and Glacis's of Squares, and after what Manner they are to be drawn: Obſerve then what follows.

	Fathoms	*Feet*
1. The Baſe of the Rampart	11	00
2. The Baſe of the Parapet	03	00
3. The firſt Banquet	00	$01\frac{1}{3}$
4. The ſecond Banquet	00	02
5. The Moat from 16 to	20	00
6. The Covert-Way	04	00
7. The Place of Arms	13	00
8. The Glacis	36	00

In caſe the Ground will give you leave to take more, you may do it.

The Explanation of this Table.

1. Take eleven Fathoms, and carry them parallel to the Courtains, Flanks, Faces, Briſures, and hollow Towers, on that Side toward the Inſide of the Place, to know after what Manner you

are to draw the Parallel to the hollow Tower: Put theſe eleven Fathoms before; then open your Compaſſes to the Point from whence you drew your hollow Tower, and draw from the ſame Point through the ſaid eleven Fathoms a crooked Line, till it joins the Baſis of the Briſure and the Face.

2. Take three Fathoms, and carry them in the ſame Manner parallel to the Deſign, to the end the Baſis of the Rampart may be oppoſite to it, and parallel. But you ought to make this Parapet, or three Fathoms, parallel alſo to the Orillon, as far as the Briſure: For there it is, that the Parapet of the Orillon ought to end. As for the hollow Towers, put, as already has been ſaid, three Fathoms, for that is the Breadth of the Parapet, before the hollow Tower, and open the Compaſs to the Point from which you drew the hollow Tower, and the Baſe of its Rampart, to draw from the ſame Point through the three Fathoms put before the hollow Tower a crooked Line joining the Parapet of the lower Briſure, and the Prolongation of the upper Briſure together; and there, where I touch the ſaid Prolongation, from thence I draw a ſmall Line to the next Briſure.

3. Take a Foot and a half, and draw with that Diſtance a Parallel round about the Parapet, toward the Baſe of the Rampart, which will repreſent to you the firſt Banquet; round about which you muſt draw another Parallel of two Feet to mark out the ſecond.

4. To draw the Breadth of the Moat, take from ſixteen to twenty Fathoms, and draw with that Diſtance a Parallel to the Faces, till they interſect

one another before the Courtain. To draw this Parallel round about the Point of the Baſtion, you muſt put the Compaſs of the Overture from ſixteen to twenty Fathoms upon the ſaid Point of the Baſtion, and draw a little Rounding from thence to the Parallels of the Faces.

5. To mark out the Covert-way, take from four to five Fathoms, and carry a Parallel to the Moat; but ſet it from a Point before the Rounding.

5. Where the Covert-way makes a ſaliant Angle, for Example in G, put there ten Fathoms to each Side, as G, J, and G, H, and afterwards with fifteen Fathoms you ſhall make Points where the ten Fathoms terminate, and draw from the ſaid Points, in the Point of the Interſection, ſtreight Lines; and this is that which is called the Place of Arms.

7. Take thirty-ſix Fathoms, or as much as the Ground will permit, and bring a Parallel round about the Covert-way, and the Place of Arms to mark out the Glacis or Parapet of the Covert-way. And thus your Square will be perfectly finiſhed.

CHAP. IV.

Of the Structure of the Half-Moon before the Courtain of the Square.

FROM the Angle of the Moat, or Counterſcarp, raiſe a Perpendicular as long as the Demi-Courtain, with its Briſure for the capital P, Q. Obſerve that in Polygons the Capital ought to be forty-five Fathoms in Length.

2. From the Point Q draw a ſtreight Line toward the Orillon of the Baſtion, terminating on the Side of the Moat in S and D.

3. Take five Fathoms, and put them from S and D, upon the Counterſcarp, toward the Inſide of the Half-Moon, as E F.

4. Put the Rule perpendicularly upon the Courtain of the Body of the Place, and erect from the Points E F, two ſmall ſtreight Lines, till they cut the Faces of the Half-Moon, as in V H, and the Lines E V, F H, will make you the Flanks of the Half-Moon.

5. Draw the Baſe of the Rampart A B, of eight Fathoms, parallel to the Faces, and the Flanks of the Half-Moon toward the Inſide, as alſo the Parapet A C, of three Fathoms, the firſt Banquet of one Foot and a half, the ſecond of two Feet.

6. Take twelve Fathoms for the Wideneſs of the Moat, which ought to be drawn parallel to the Faces, but not to the Flanks: You muſt give it alſo its Rounding before the capital Point.

7. The Covert-way, Place of Arms, and Glacis, are made as in Chap. 3. L. 3. Sect 5, 6, 7. See the Plate C.

CHAP. V.

Of the Structure of the Ravelin before the Courtain.

THIS Work is done as the Half-Moon, when you allow it no Flanks.

Sect. 2.

Sect. 2. *To make a Ravelin with Lunettes.*

Having raiſed the Ravelin as it ought to be done,

1. Take two Parts of the Flank of the Body of the Place, and put them at the Angle of the two Moats; that is, from the Moat of the Body of the Place and that of the Ravelin, upon the Counterſcarp, to mark out the Demi-Gorges of the Lunettes, as A B, and A C.

2. Take the Flank of the Body of the Place entire, and draw from the Point B C, two Arches to cut one another in D, and then join B D, and C D, together by a ſtreight Line, to have the Faces of the Lunettes.

3. You draw the Moat of theſe Lunettes from the half of that of the Body of the Place, allowing it alſo a Rounding.

4. The Baſe of the Rampart, the Parapets, and the Banquets, is made as for the Ravelin. See the Plate D, Fig. V.

Sect. 3. *To make a Ravelin with Counter-guards.*

Having made the Ravelin alone with its Moat in the ſame Manner as has been ſet down.

1. Prolong the Faces of the Ravelin above its Moat, and from the Interſection of that Line and of the Moat put upon the Prolongation thirty Fathom, as A B.

2. Put fifteen Fathoms upon the Counterſcarp of the Moat of the Body of the Place, placing the Compaſs in the Angle of the two Moats, as C D.

3. Join DB together by a right Line, which Side, and the other AB, muſt be fortified with a Rampart, Parapet, Banquets, Moats, Covert-Way, and Glacis, like the Ravelin itſelf, the Diſtances of which are alſo here to be obſerved.

4. Having fixed this Work on the other Side of the Ravelin, place a ſmall Reduit at the Head between the two Counter-guards, which are thus to be raiſed: Firſt, where the Moats of the Counter-guard interſect one another, erect from the ſame Angle a Perpendicular of twenty Fathoms, as EF; then divide the Faces of the Counter-guards into two equal Parts, as BG and AG, and from the capital Point of your Reduit draw a right Line toward the middle of the Faces, marked by the Point G, terminating on the Side of the Moat of the Counter-guards in H, and the Line FH will be the Face, which is only to be fortified with a Rampart, Parapet, Moat, Covert-Way and Glacis, if need require. See the Plate C, Fig. VI.

Sect. 4. *To make a Ravelin, to be placed at the Entrances into Places.*

1. Having the Place for a Ravelin, you muſt erect a Perpendicular of twelve Fathoms from the Angle of the Counterſcarp, as AB.

2. You muſt put at the ſame Angle ſix Fathoms upon the Counterſcarp for Demi-Gorges, as AC, and AD.

3. Erect upon the Points CD Perpendiculars of four Fathoms for the Flanks.

4. Join the Flanks and the Capital together to have the Faces.

5. Draw a Moat round about this Work of two Fathoms and a half, parallel only to the Faces, and round before the Point. In this little Work is placed a great *Corps du Gard*, the better to guard the Gate and the Bridge, and preſent the Arms to the Officers.

6. That which is left of the Place deſigned for the Ravelin ought to be joined together, as if the *Corps du Gard* were not there, and fortified with Ramparts, Parapets, *&c.* as another Ravelin. See the Plate D, Fig. VII.

CHAP. VI.

To make a Horn-work before the Courtain.

1. ERECT a Perpendicular from eighty-five to eighty-eight Fathoms at the Point of the Ravelin or Half-Moon, as Q G.

2. Draw from the Point G to each Side an Arch of ſixty Fathoms.

3. Take from 114 to 118 Fathoms, which is moſt uſual, and reſect theſe Arches in E F, at the Angle of the two Counterſcarps D R.

4. Join E D together by a ſtreight Line, as alſo F R and F E.

5. Divide the Lines E F into two equal Parts, from the Middle of which ſet down a Perpendicular of twenty Fathoms G H.

6. Draw the Faces as for the Body of the Place; their Length is thirty-eight Fathoms.

7. For the Complement of the Line of Defence take twenty-one Fathoms two Feet, which join together after the End of the Face and of the Complement, to have the Flanks: Draw the Courtain alſo.

8. To make the Orillon and the hollow Tower go the ſame Way as is ſet down in Lib. III. Chap. II. only that you do not divide the Flank but into two equal Parts; Monſieur *de Clermont* would have allowed to the Orillon of the Square two fifth Parts of the Flank.

9. The Baſe of the Rampart is to contain eight Fathom; that of the Parapet three; that of the Moat twelve; that of the Covert-way five; the firſt and ſecond Banquet are to have the ſame Wideneſs as has been mentioned above.

The TABLE.

	Fathoms	*Feet*
The Capital Q G	88	00
The Wing DE	118	00
The Perpendicular GH	20	00
The Face EL	38	00
The Flank LN	15	03
The Complement, *&c.* HN, HM	21	03
The Courtain MN	38	05
The Line of Defence EM	84	04
The Baſe of the Rampart	08	00
The Baſe of the Parapet	03	00
The firſt Banquet	00	01½
The ſecond Banquet	00	02
The Wideneſs of the Moat	12	00

To make a Ravelin before theſe Horns.

1. From the Angle of the Moat of the Horns erect a ſtreight Line of twenty-four Fathom for the Capital O P.

2. From the Point B draw right Lines toward the Orillon of the two Baſtions of the Horns terminating at the Moat, as O Q, O Q.

3. Draw the Baſe of the Rampart, and the other Diſtances, as in the working of the Horn-work, nly that the Moat ought not to be wider than eight Fathoms, nevertheleſs it muſt have its Rounding.

4. The Covert-way, the Places of Arms, and Glacis, are made as in the Body of the Place. See he Plate C, Chap. 4. Line 3.

CHAP. VII.

To make a Horn-work before the Baſtion.

FROM the Point of the Baſtion draw a ſtreight Line of eighty-ſix Fathoms, AB.

2. From the Point B draw to each Side an Arch f ſixty Fathoms.

3. Take from 118 to 120 Fathoms, and reſect hoſe two Arches in CD, the Angles where the Moat of the Ravelin throws itſelf into the Moat of he Body of the Place, as EF.

4. Join EC, CD and DF, together by ſtreight Lines.

5. Divide the Line CD into two equal Parts, rom the Middle of which draw down a Perpendicular from eighteen to twenty Fathoms, as BH.

6. Draw the Faces as uſually; their Length is to e thirty-eight Fathoms, as KI; the Complement twenty-one Fathoms two Feet, as LN; laſtly, ll the reſt is done as in the Horn-work before the Courtain, the Parts of which have the ſame Diſtance. See the Plate E, Fig. VIII.

CHAP.

CHAP. VIII.

To make a Horn-work with Shoulders.

1. PRolong the Flanks towards the Field to th Length of the Courtain A B, C D.

2. From B and D draw a Perpendicular fro twenty-five to twenty-eight Fathoms, as BE, D

3. From the Points E F raiſe other Perpendicu lars from 118 to 120 Fathoms, as E G, H F.

4. Join G H together by a ſtreight Line, whic you ſhall divide into two equal Parts, and from t Middle of which you muſt bring down a Perpe dicular of twenty Fathoms, as I K.

5. Draw the Faces as uſually, the Length which muſt be thirty-five Fathoms.

6. The Complement of the Line of Defence found, by putting the Compaſs upon the Extremi of the two Faces, and then keeping one Point the Compaſs ſtanding in its Place, let the other fa upon the Line of Defence. Which is alſo to done on the other Side, as L M, N O.

7. L M and N O are drawn together for t Flanks, as alſo M O for the Courtain.

8. To have the Orillon, take two fifth Parts the Flank of this Work; the reſt is made as uſual in like Manner as the hollow Tower, or Fla retired.

9. The Baſe of the Rampart, *&c.* ought to ha the ſame Wideneſs as the reſt of the Horn-work and to be drawn parallel as far as the Moat of t Body of the Place.

10. The Ravelin before this work is made as ready has been ſet down in Chap. VI. Lib. III. S the Plate F, Fig. IX.

CHAP. IX.

To make a Horn-work with a Crown.

DIvide the exterior Polygon of the Horn-work into four equal Parts, A B C D.

2. Take three Parts of theſe four, and deſcribe em with an Arch at the Angle of the Moat of the id Work E.

3. From the Point E erect a Perpendicular as far the Arch F.

4. Put the ſame three Parts of the Point F upon at Arch, as F G and F H, and join F G and F H gether by a right Line.

5. From the Line F G and F H, let fall a Per-ndicular of ſixteen Fathoms, as I K, L M; then aw the Faces as uſually, of which let the Length twenty-nine Fathoms.

6. For the Complement of the Line of Defence ke fifteen Fathoms, and then draw the Flanks and e Courtain as above.

7. Prolong the Faces of the Horns to twenty-ven Fathoms, as A N, D O, and join G N and O together by a right Line.

8 Put twenty-four Fathoms upon the Wing of orn, on the Side of the Place at the Point A D, A P and D Q.

9. From the Points N and O draw right Lines wards the Points P Q, which terminate on the de of the Moat of the Horn-work in R S.

10. To make the Orillon, divide the Flank into o equal Parts, of which the one ſerves for the id Orillon, and the other for the retired Flank. ou are to obſerve, that the Flanks which join eir Faces to the Moat of the Horn-work, are

left without an Orillon and a retired Flank, a N R, O S.

11. The Baſe of the Rampart, *&c.* and all th other Diſtances, are formed as in the Horn-work See the Plate F, Fig. X.

CHAP. X.

To make a Crown-work before the Courtain.

1. FROM the capital Point of your Raveli erect a Perpendicular of 100 Fathoms, an if there be no Ravelin, take the Courtain of th Body of the Place with the Briſure to draw tw Arches which interſect one the other before th Courtain. From which Point of Interſection yo muſt do as I have already ſaid concerning the capital Point of the Ravelin, as A B.

2. Take the ſame 100 Fathoms, and make a Arch from the Point B to each Side.

3. Take 113 Fathoms, and reſect thoſe tw Arches at the Beginning of the Orillon C D and E F

4. Join E B and B F together by right Line and draw right Lines from the Points E F toward the Orillon of the Place, terminating upon the Sid of the Moat G H.

5. Divide the Line E B, and the other B F, int two equal Parts, from the Middle of which let fa Perpendiculars, each from fifteen to ſixteen Fathoms, as I M, L N.

6. You are to draw the Faces as uſually, th Length of which muſt be thirty-one Fathoms, a O P, Q R; the Complement, *&c.* of ſixteen Fathoms, as S T, V W: The Flanks and Courtai are made, as already has been frequently ſhewed.

7. Divide the Flank into two equal Parts, of which reſerve one for the Orillon, and the other for the retired Flank.

8. The Baſe of the Rampart takes up eight Fathoms, that of the Parapet three; the firſt Banquet a Foot and a half, the ſecond two Feet; the Wideneſs of the Moats twelve Fathoms; in the Covert-way and Glacis obſerve the ſame Breadth as there is round about the Body of the Place. See the Plate G, Fig. XI.

The Table for this Work.

	Fathoms	*Feet*
The capital Line A B	100	00
The exterior Sides B E, B F	100	00
The Wings E C and F D, with their Complements to the Orillons	113	00
The Perpendicular	17	00
The Face	31	00
The Flank	13	03
The Courtain	30	00
The Complement of the Line of Defence	16	00

CHAP. XI.

To make a Crown-work before the Baſtion.

1. ERECT upon the capital Line of the Baſtion a Perpendicular of 100 Fathoms, as A B.

2. From the Point B draw to each Side an Arch of 100 Fathoms.

3. Take ninety-two Fathoms, and reſect thoſe Arches at the Concourſe of the two Moats, *viz.*

That of the Ravelin, and that of the Body of the Place, in CD, as ED, FC.

4. Join CB, BD, FC, and ED, together by ſtreight Lines.

5. Divide the Lines CB and BD into two equal Parts, from the Middle of which let fall a Perpendicular of ſeventeen Fathoms.

6. You muſt draw the Faces, as uſually, allowing to the Length of them thirty-one Fathoms; to the Complement, *&c.* ſixteen Fathoms; to the Flank, thirteen Fathoms three Feet; to the Courtain, twenty-nine Fathoms three Feet; to the Baſe of the Rampart eight Fathoms; to the Baſe of the Parapet three Fathoms; and to the Banquets, Covert-way, and Glacis, as uſually. See the Plate H, Fig XII.

CHAP. XII.

To make a Ravelin before the Point of a Baſtion.

1. PRolong the Parapet of the Body of the Place above the Moat, ſo that it may cut it in Q S.

2. From the Point of the Baſtion erect a right lined Perpendicular, upon which put thirty-ſix Fathoms, beginning at the Moat, as C V for the Capital.

3. Upon the Prolongation of the Parapet by the Point S Q, put fourteen Fathoms for the Length of the Flanks, as S T, Q R.

4. Join T V, V R, together, and you will have alſo the Faces.

5. Round about the Faces of the Flanks you ſhall draw the Baſe of the Rampart of eight Fathoms;

that of the Parapet thirteen Fathoms, and the two Banquets as uſually; and the Moat of twelve Fathoms, parallel to the Faces and the Flanks, with its Rounding, before the capital Point V, and the Flanks T R. See the Plate I, Fig. XIII.

CHAP. XIII.

To make a ſingle Tenail.

1. PRolong the Flanks of the Body of the Place to 110 Fathoms, as A B C D.

2. Join B D together by a right Line; divide it into two equal Parts, and let fall from the Middle a Perpendicular of twenty-ſix Fathoms, as E F. But you muſt obſerve that this Line ought not to be longer than twenty or twenty-two Feet, when there is a Ravelin or a Half-Moon before the Courtain of the Body of the Place.

3. Draw the Extremities of the Wings in the Point F, as B F, and D F.

4. Draw the Baſe of the Rampart eight Fathoms, that of the Parapet three, the two Banquets as uſually, the Moat twelve Fathoms, the Covert-way and Glacis as for the Body of the Place.

The Ravelin before the Work.

1. Divide the Faces of the Tenail B F and F D, into two equal Parts, and ſet the Half of the one upon the Perpendicular erected upon the Angle of the Counterſcarp, as G P.

2. From the Point G, toward the Middle of the ſaid Faces of the Tenail, draw right Lines for the Faces of the Ravelin, as G L, and G M.

3. The Diſtances for the Body of the Place of the Ravelin are the ſame with thoſe of the Tenail, only that the Moat belonging to it is no wider than eight Fathoms. See the Plate K, Fig XV.

CHAP. XIV.

To make a double Tenail.

1. PRolong the Flanks of the Body of the Place to 110 Fathoms, as A B and C D, and join B D together by a right Line.

2. Divide the Line B D into two equal Parts, and let fall from the Middle of it a Perpendicular o twenty-ſix Fathoms, as E F.

3. From the Points B D draw right Lines to th Point F for the Faces, each of which muſt be divided into two equal Parts, as B G, D H.

4. Erect a Perpendicular upon the Angle of th Faces of forty-five Fathoms, as F J.

5. From the Point J, draw the Counter-Faces i the Points G H.

6. To the Wings, to the Faces, and Counter-Faces, draw the Baſe of the Rampart parallel o eight Fathoms, and all the other Diſtances as in th ſingle Tenail. See the Plate K, Fig. XVI.

CHAP. XV.

To make a Baſtion with Counter-Guards.

FOrmerly they were wont to put theſe Work before the Baſtion, the better to cover them The Structure is thus.

1. Dra

1. Draw Lines parallel to the Faces of the Baſtion of fifteen Fathoms, terminating upon the Counterſcarp of the Ravelin or Half-Moon, and forming a Point before the Point of the Baſtion, as A B C.

2. Draw the Baſe of the Rampart to theſe two Faces of eighteen Fathoms, as E D. All the other Diſtances are the ſame with thoſe of the Ravelin or Half-Moon. See the Plate I, Fig. 14. C. XII. L. III.

CHAP. XVI.

Of the Structure of a Pentagon.

	Fathoms	*Feet*
1. THE Semi-Diameter	153	01
2. The exterior Side AB, CDJ,	180	02
3. The Perpendicular E F	25	00
4. The Face A F	50	00
5. For the Complement of the Line of Defence F G, take	38	03
6. The Line of Defence G B	131	03
7. The Flank J G	22	02
8. The Courtain G H	73	04

The Explanation of this Table.

See Chap. 2. Book 3. There you will find all that is neceſſary for the Structure of a Pentagon; provided you take the Diſtances preſcribed here, for thoſe that are mentioned in the ſame Place. See the Plate F, Fig. 16.

Of the Structure of a Tenail in the Moat.

To juſtify what has been ſaid above of the Line of Defence, obſerve this Work, the Structure of which is thus:

1. Set the Rule upon the advanced Flank of the Body of the Place, and draw parallel to that Flank from five to ſix Fathoms, which touches the Line of Defence before the Orillon in E B.

2. Divide the reſt of the Line of Defence from B E, to the neareſt Angle C, into two equal Parts, as B F, E G.

3. Take the Diſtance F G, between the Points of the Compaſs, leaving one upon the Point F: Carry the other from the Point G upon the Complement of the Line of Defence, marked F. Then fix one Point of the Compaſs upon the Point G, and carry the other from F, upon the other oppoſite Complement, marked H. Then join H F and J G together, to form the Flanks: Do the ſame for the Courtain H J.

4. Draw the Baſe of the Rampart of eight Fathoms to the Faces, and to the Flanks of the Tenail; and to the Courtain from four to five Fathoms. Then the Baſe of the Parapet of two Fathoms three Feet round about. You ſhall make the two Banquets as uſually. See the Plate M, Fig. 16.

* * *

CHAP.

CHAP. XVII.

Of the Structure of a Hexagon, and other Polygons.

	Fathoms
1. THE Semi-Diameter takes up	180
2. The exterior Polygon	180
3. The Perpendicular	27
4. The Face	50
5. For the Complement of the Line of Defence	38
6. The Line of Defence	136
7. The Flank	25
8. The Courtain	71

The other Diſtances are equal to thoſe of the Pentagon.

Sect. 2. *The Heptagon.*	*Fathoms*	*Feet*
1. The Semi-Diameter takes up	207	03
2. The exterior Side	180	00
3. The Perpendicular	27	00
4. The Face	50	00
5. For the Complement, *&c.*	38	00
6. The Line of Defence	135	03
7. The Flank	24	00
8. The Courtain	72	03

Sect. 3. *The Octagon.*		
1. The Semi-Diameter takes up	238	01
2. The exterior Polygon	180	00
3. The Perpendicular	28	00
4. The Face	50	00
5. For the Complement, *&c.*	28	00
6. The Line of Defence	137	03
7. The Flank	25	04
8. The Courtain	71	04

Sect. 4. *The Enneagon.*

	Fathoms	*Feet*
1. The Semi-Diameter	263	01
2. The exterior Polygon	180	00
3. The Perpendicular	32	00
4. The Face	50	00
5. For the Complement, *&c.*	38	00
6. The Line of Defence	138	00
7. The Flank	29	00
8. The Courtain	70	03

Sect. 5. *The Decagon.*

1. The Semi-Diameter	291	03
2. The exterior Polygon	180	00
3. The Perpendicular	36	00
4. The Face	52	00
5. For the Complement, *&c.*	38	00
6. The Line of Defence	135	00
7. The Flank	32	00
8. The Courtain	70	00

Sect. 6. *The Hendecagon.*

1. The Semi-Diameter	319	00
2. The exterior Polygon	180	00
3. The Perpendicular	37	00
4. The Face	152	00
5. For the Complement, *&c.*	38	00
6. The Line of Defence	135	00
7. The Flank	32	00
8. The Courtain	70	00

Sect. 7. *The Dodecagon.*

	Fathoms	*Feet*
1. The Semi-Diameter	347	04
2. The exterior Polygon	180	00
3. The Perpendicular	42	00
4. The Face	52	00
5. For the Complement, *&c.*	38	00
6. The Line of Defence	137	00
7. The Flank	37	00
8. The Courtain	69	00

CHAP. XVIII.

To make the Profil.

HAVING now treated of the Breadths and Lengths of the Parts of a Place, it is requiſite to ſay ſomething of the Height of the ſaid Parts; or rather after what Manner to make the Profil of a Place. To which Purpoſe two things are to be obſerved:

1. That you erect the Profil of the exterior Works after the ſame Manner as that of the Body of the principal Place; provided that you apply thereto the Heights, of which I ſhall ſpeak as much as is neceſſary to be known, whereof the Breadths have been above exhibited.

2. That ten Fathoms of the Scale, of which I make uſe in delineating the Body of the Place, make but one, when I would make the Profil of the ſame Place. So that 100 Fathoms which I have applied to the Body of the Place, for this Purpoſe, afford only a Length of ten Fathoms.

The Profil of the Body of the Place.

For example's ſake, let us make the Profil of a Pentagon; and then obſerve that which follows.

1. Draw a long right Line, and there mark eleven Fathoms for the Baſe of the Rampart, beginning at the left Hand, as AB.

2. Put off one Fathom four Feet immediately behind the Point A, upon the ſame Line as AC. This Triangle marks out the interior *Talus.* And to mark out the exterior *Talus*, put one Fathom immediately before B, as BD. But in the Field you muſt allow a larger *Talus* to the Rampart, according to the Nature of the Ground.

3. Erect upon CD two Perpendiculars, each of which contain three Fathoms in Height, as CE, DF, and then join AE, EF, and FB, by a right Line, and that will afford the Height of the Rampart with its *Talus.*

4. Put four Fathoms of the Point E toward the right Hand, to mark out the Platform of the Rampart, as EG.

5. Erect upon G a ſmall Perpendicular of a Foot and a half, for the Height of the firſt Banquet, as GJ. Then draw from the Point J a Parallel to the Height of the Rampart a Foot and a half broad, as JH; that is the Breadth of the Banquet. Then ſet another Perpendicular upon the Point H, of the ſame Height as HI; and from the Point J draw alſo another Parallel of two Feet broad, as LM, and then you will have both the Banquets.

6. Put four Feet immediately behind the Point G, as GN, and then upon that Point erect a Perpendicular of eight Feet, and NO; which done, join

the Point M and the Point O together, to get the interior Height of the Parapet with its *Talus*.

7. Prolong the exterior *Talus* BF two Feet farther, as H P, and join O P together to have the Breadth of the Parapet with its exterior *Talus*.

8. Put four Feet upon the firſt Line behind the Point B, as BQ; from which Point let fall the Perpendicular Q R, of three Fathoms, and join BR together for the Scarp. Which done, put twenty Fathoms behind the Point B, for the Breadth of the Moat, as B S; then put two Points before the Point S, as S T; from whence let fall another Perpendicular of three Fathoms, as T V; then join V S together to have the Counterſcarp of the ſame R V, and ſo the Moat will be entirely repreſented.

10. After this take thirty-ſix Fathoms, ſo far as the Ground will permit, and put them behind the Point W, upon the ſame firſt Line, as WA, and then join them together by a ſtreight Line, to repreſent the Glacis. After this Manner you ſhall have the Body of the Place according to its Lengths, Breadths, and Heights. See the Plate N, Fig. 17.

The Profil of exterior Works.

The Profil is made as the preceding in reſpect of the ſeven firſt Points, ſaving only that the Baſe of the Rampart be no broader than eight Fathoms, nor the Rampart higher than fourteen Feet. As to the eighth Point of the Deſcription of the preceding Profil, the only Difference conſiſts in this, that the Moat is not larger here than twelve Fathoms, nor deeper than two and a half. All the reſt is done as in the preceding. See the Plate N, Fig. 18.

CHAP. XIX.

How to trace out the Draught of a Fortreſs i the Field.

AFTER you have ſeen the Manner of fortify ing upon Paper, it is requiſite for an Eng neer, or any one that would diſcourſe of Fortreſſe to underſtand of what Breadth, Height, and Depth their Parts ought to be; whence the one or th other Part derives its Defence, whether it be neceſ ſary to fortify one Part more than another; wher to attack a Place, and after what Manner to fruſtrat the Enemy's Deſign. We ſhall therefore now ſhe how to trace out a Fortreſs in the Field: To whic Purpoſe it is neceſſary to know which are th Angles of the exterior Polygons; being theſe tha follow.

The Angle of the exterior Polygon.

	Degre
The Angle of a Square is of	9
That of a Pentagon of	10
Of a Hexagon of	1
Of an Heptagon of	12
Of an Octagon of	13
Of an Enneagon of	14
Of a Decagon of	14
Of an Hendecagon of	14
Of a Dodecagon of	15

Th

The Explication of this Table.

For Example: If you would draw a Polygon of ive Baſtions, which is called a Pentagon, of which very exterior Polygon muſt have the Length of he Line given A B, which is 180 Fathoms, then roceed thus:

1. Fix the Staff upon which you have your Aſtrolabe, in the Hole that is made by the little eg B, ſo that you may ſee through both the ights of the Aſtrolabe, from the Point B, or he Place where your Inſtrument is fixed, the eg A.

2. Count from the left Hand towards the right n Angle of 108 Degrees, which is the Angle of he exterior Polygons, to the Pentagon, (if you ake an Hexagon, you take this Angle of 120 egrees, *&c.*) there fix a little Peg, which you ay ſee through the movable Sights, for Example, : That done, fix a Cord or a Chain to the Peg , and draw a ſtreight Line toward the Point C, pon which you ſhall then put the Length of the rſt Line given A B, as B D.

3. Put the Inſtrument upon the Point D, ſo that hrough its Diopters or Sights you may ſee the Peg . Then ſeek by the Diopters an Angle of 108 egrees, and there fix another Peg, which you may e through the Diopters, as D E. That done, aw a ſtreight Line from the Point D to the Point , and then put the Length of the Line B D upon e Line D E, as D F.

4. Do this as many Times as is requiſite for a entagon.

5. Divide the Flank into three equal Parts, and the firſt alſo into two others, in the Middle of which fix the Peg H. Then faſten the Chain to the Point H, and draw the Rounding, as upon Paper, with the Compaſs: That done, draw the Briſures of five Fathoms, and make in their Extremities two Arches to cut each other in I. Then fix in the Place of the Point I a little Peg, and with the Chain that is faſtened to it, you ſhall draw the retired Flank.

6. To make the Rounding of the Moat, ſet the Peg upon the Point of the Baſtion or Ravelin, and with the Chain draw the Rounding. See the Plate O, Fig. XIX, XX.

CHAP. XX.

To make the Streets in a Fortreſs.

1. DRAW to the Courtains of the Place a Parallel of ten Fathoms for the Place of Arms near the Rampart.

2. Draw all the Points made of that Line before the Baſtion of the Place; for Example A B C D E.

3. Take the Demi-Gorge of the Place, or which is better, thirty Fathoms, and put them from the Center upon thoſe Lines A B C D E, as a b c d e: Which Diſtances join together likewiſe by right Lines.

4. Take three Fathoms, and ſet them off from the Points A a, towards B b and C c, as F f, G g, which muſt alſo be done afterwards from B b, C c, D d, E e, *&c.*

5. Join F f and G g together by right Lines.

6. Take eight Fathoms of the Line F f, and divide the reſt into three equal Parts. Then take one Part of the three, and place it at the Points F and G, upon the Lines drawn in the grand Place of Arms, as F G, G L. Which done, put four Fathoms upon the ſame Lines, after the Points H L, as H M, L N. Laſtly, join H L and M N together by right Lines.

7. Take the ſecond Part of the three firſt, and put them after M N upon the ſame Lines, as M O, N P, and join the Line O P together. Which done, you ſhall replace four Fathoms after the Points O P, as Q R, and then likewiſe join Q R together.

8. Divide each Side, F G, f g, into two equal Parts, as S T, and join the Lines S T together by a right Line. Then put three Fathoms on each Side of the Points S T, as S s s, T t t, and draw S T together; and theſe will form the Streets of your Fortreſs. See the Plate P, Fig. XXI.

* * *

BOOK IV.

CHAP. I.

Of the principal Angles of a Fortreſs.

THIS Book contains the Explication o the Parts of a Fortreſs, whereof we hav already ſpoken: By which are to be underſtood the Cavaliers, the Streets, th Places of Arms, the Counter-Guards, the Magazines, Gates, Back-doors, Draw-Bridges, Bridge and other Things. But we ſhall firſt begin to trea of the Angles.

Sect. 1. *To find the Angle of the Center of ever regular Fortreſs.*

Divide the Circumference of the Diamete which contains 360 Degrees, by the Number o the Baſtions of your Fortreſs, and the Produ of that Diviſion will make the Overture, or Angle of the Center. Fo Example: Let us ſeek the Angle o the Center of a Pentagon; to whic Purpoſe, you muſt divide 360 Degre by 5. For in regard our Fortreſs has no mo than five Baſtions, a larger Diviſor cannot b taken: So that the Product of the Diviſion b in

1
360(72
55

ing 72, we muſt ſay, that the Angle of the Center of a Pentagon has 72 Degrees of Overture.

Sect. 2. *To find the Angle of the Gorge, as it is called after* Vauban's *Manner; or the Angle of exterior Polygons.*

To find that Angle there needs no more than to ſubſtract the Angle of the Center of the ſame Fortreſs of 180 Degrees, and that which remains makes the Angle of the Gorge. For Example: If you would know the Angle of the Gorge of a Pentagon, you muſt from 180 Degrees ſubſtract 72; for that is the Angle of the Center of a Pentagon: Then obſerve what remains, which will be 108 Degrees, and ſay, That the Angle has 108 Degrees of Overture.

$$\begin{array}{r} 180 \\ 72 \\ \hline 108 \\ \hline \end{array}$$

Sect. 3. As for the Angle of the Baſtion, and all the reſt, it is impoſſible to know what their Overtures are, in regard they are not always the ſame: So that it depends upon the Knowledge of the Engineer to make the Flank, ſo that they may form a good Angle of the Baſtion, according to which almoſt all the reſt take their Meaſures. Conſult our Authors upon this Matter. Nevertheleſs we ſhall here ſet down the Overtures of the principal Angles after our Manner of Fortification.

In a Square.

	Deg.	*Min.*
1. The Angle of the Center is	90	00
2. The Angle of the Gorge	90	00
3. The Angle of the Baſtion	63	00

	Degr.	*Min.*
4. The Angle of the Courtain	98	30
5. The Angle forming the Flank	81	30
6. The Angle forming the Front	112	30
7. The flanking Angle	67	30

In a Pentagon.

1. The Angle of the Center is	72	00
2. The Angle of the Gorge	108	00
3. The Angle of the Baſtion	77	00
4. The Angle of the Courtain	101	50
5. The Angle forming the Flank	78	10
6. The Angle forming the Front	116	00
7. The flanking Angle	64	00

In a Hexagon.

1. The Angle of the Center is	60	00
2. The Angle of the Gorge	120	00
3. The Angle of the Baſtion	87	00
4. The Angle of the Courtain	106	00
5. The Angle to form the Flank	74	00
6. The Angle to form the Front	121	40
7. The flanking Angle	58	20

In a Heptagon.

1. The Angle of the Center is	52	00
2. The Angle of the Gorge	128	00
3. The Angle of the Baſtion	95	00
4. The Angle of the Courtain	102	30
5. The Angle to form the Flank	77	30
6. The Angle to form the Front	120	00
7. The flanking Angle	60	00

In an Octagon.	Degr.	Min.
1. The Angle of the Center is	45	00
2. The Angle of the Gorge	135	00
3. The Angle of the Baſtion	100	00
4. The Angle of the Courtain	103	00
5. The Angle to form the Flank	77	00
6. The Angle to form the Front	121	00
7. The flanking Angle	59	00

In the Enneagon.		
1. The Angle of the Center is	40	00
2. The Angle of the Gorge	140	00
3. The Angle of the Baſtion	190	00
4. The Angle of the Courtain	106	00
5. The Angle to form the Flank	74	00
6. The Angle to form the Front	125	00
7. The flanking Angle	55	00

In a Decagon.		
1. The Angle of the Center is	36	00
2. The Angle of the Gorge	144	00
3. The Angle of the Baſtion	100	00
4. The Angle of the Courtain	93	00
5. The Angle to form the Flank	87	00
6. The Angle to form the Front	115	00
7. The flanking Angle	65	00

In an Hendecagon.		
1. The Angle of the Center is	33	00
2. The Angle of the Gorge	147	00
3. The Angle of the Baſtion	100	30
4. The Angle of the Courtain	101	30
5. The Angle to form the Flank	78	30
6. The Angle to form the Front	125	00
7. The flanking Angle	55	00

In a Dodecagon.

	Degr.	*Min*
1. The Angle of the Center is	30	00
2. The Angle of the Gorge	150	00
3. The Angle of the Baſtion	100	00
4. The Angle of the Courtain	101	30
5. The Angle to form the Flank	78	30
6. The Angle to form the Front	128	00
7. The flanking of the Angle	52	00

Sect. 4. *Of the Angle of the Baſtions.*

This Angle has occaſioned great Diſputes amongſt the moſt Part of the Ancients, who hav treated of Fortification: For ſome were of Opinion, that this Angle was to be always acute others, that it only ought to be ſo in the Hexagon and that it ought to be right in Figures of mor than ſix Baſtions; and this was the uſual Practic of Monſ. *Antonine de Ville.* Others there are wh maintain the contrary, and ſay, That the acut Angle is never to be allowed of, but in Figure that are under ſix Baſtions, and that it alway ought to be obtuſe in a Fortreſs which exceed that Number. True it is, that the greateſt Number have been for the right Angle: and it were ſort of Ignorance to maintain the contrary. *Monſheuſer* made choice of this Angle in a Square 60 Degrees, in a Pentagon of 72 Deg. in a Hexagon of 80 Deg. in a Heptagon of 85 Deg. 43 M in an Octagon to a Hendecagon of 90 Deg. *Freitag* made choice of this Angle from a Tetragon 65 Deg. to a Pentagon of 74 Deg. from a Hexago of 80 Deg. to a Heptagon of 84 Deg. 17. Mi fro from an Octagon of 87 Deg. 30 Min. and from an Enneagon to a Dodecagon of 90. But he ſoon altered his Opinion, maintaining that this Angle ought to be from a Tetragon of 60 Deg. to a Pentagon of 69; from an Hexagon of 75, to a Heptagon of 79 Deg. 17 Min. from an Octagon of 82 Deg. 30 Min. to an Enneagon of 85 Deg. to a Decagon of 87 Deg. to an Hendecagon of 88 Deg. 38 Min. to a Dodecagon of 90 Deg. *Goldman* makes uſe of this Angle for a Square of 65 Deg. for a Pentagon of 69 Deg. for a Hexagon of 75 Deg. for a Heptagon of 79 Deg. 17 M. for an Octagon of 82 Deg. 30 Min. for an Enneagon of 85 Deg. for a Decagon of 87 Deg. for an Hendecagon of 88 Deg. 38 Min. for a Dodecagon of 90 Deg. *Paſcha* takes it for a Square of ſixty Fathoms, and augments it ſtill by five, according as the Polygon gains more of the Side. But they who have been accounted moſt ſkilful in the Art of *Fortification*, were always, as I have ſaid, for the right Angle, though it be alledged, That in making it acute, there is room for more Firing from the Courtains; or that in making it obtuſe, it is more capable to withſtand the Enemy's Batteries, and the Injuries of Time. The Reaſon that kept them ſo fixed to this Opinion, was, that in their Time they made their Breaches with the Cannon, ſo that this Angle being right, it had all the Perfection that could be deſired; whereas the making it obtuſe, diminiſhed the Capaciouſneſs of the Baſtion, and of its Flank; beſides, that the ſame Battery could play upon both Fronts: And by making it acute, the Point of it was ſo ſoon broken by the frequent Diſcharges; more eſpecially, if ſeveral Guns played at a Time; beſides, that bad Weather more eaſily ruined that Point. But to ſpeak the Truth, we ought to believe, that this Angle, whether right, acute, or obtuſe, ought never to trouble our Thoughts, provided it be not leſs than ſixty Degrees, nor much more than 100: For the Breaches are now made by Mining, wherein there is no more Trouble to carry the Point of a Baſtion with an obtuſe Angle, than with an Angle either right or acute. Moreover, there is this in it, that Breaches are rarely made in the Point of a Baſtion, but in one of the Fronts, to the end, that in paſſing the Moat the Aſſailants may not be expoſed to more than one Firing; ſo that provided the Angle be well able to reſiſt the Injuries of Time, it is enough. However, much more than 100 Degrees are not to be exceeded, becauſe that being more open, it would require the capital Line to be ſhort; in which caſe, the Baſtion would not have room ſufficient.

Sect. 5. *Of the Angle of the Courtain.*

Engineers cannot agree concerning the Overture of the Flank; ſo that every one orders it according to his Fancy. *Erhard* makes the Flank perpendicular to the Faces of the Baſtions; and his Reaſon is, becauſe the Flanks, being oblique above the Courtain, that is to ſay, making an acute Angle with it, are much more expoſed to the Enemy, and conſequently more difficult to be ruined, as not being battered by the Cannon but very obliquely: But granting that this were ſo, it is no leſs a Truth to ſay, that as they are but little expoſed, ſo neither do they not ſurvey very far; and it is impoſſible to make good Embraſures upon a Parapet, ordered after that Manner. For to play the Cannon above the Parapet, is to make it impoſſible to preſerve it in a good Condition; beſides, that a Flank diſpoſed after that Manner, can never defend the Paſſage of the Moat, nor flank the Breach, nor in the laſt Place, uncover the Covert-ways. As for Monſieur *le Chevalier de Ville*, who makes the Flank perpendicular to the Courtain, he has more Reaſon for what he does, than *Erhard*; though his Flanks are leſs than thoſe which Monſieur *Vauban* makes uſe of, and that they do not batter the Moat ſufficiently, nor the Counterſcarps, which is the moſt eſſential Part of the Defence. Beſides, it is but too well found by Experience, that when the Counterſcarp is gained, the reſt holds out but a ſhort Time, the Reaſon of which, if it be demanded, is becauſe the diſpoſing of the Places is ſo diſadvantageous, that one Day ſees them reduced to Duſt; and the Embraſures made upon theſe Parapets, perpendicular to the Courtain, are too acute; eſpecially if it be required that they ſhould clear the Covert-ways. I know it may be ſaid, that it is eaſy to make an Orillon, or Ear, and a retired Flank in a circular Faſhion: But the Orillon will be too feeble, unleſs you allow it the half of the Flank, and the Remainder will not ſuffice for its Defence, not having room enough for ſeveral Pieces to be placed upon it; beſides that, there muſt be a Mixture of great and ſmall Shot, which will cauſe an inevitable Trouble.

Monſieur *Pagan*, a Perſon experienced to Perfection in the Art of War, and one who has juſtly acquired the Reputation of being one of the moſt ſkilful Engineers of our Time, was the firſt that altered the diſpoſing of Flanks perpendicular to the Courtain, by allowing them much more Overture; for he makes them perpendicularly upon the Line of Defence; and he gives very good Reaſons for it, in his Book of Fortifications; where he ſays, That his being preſent at above twenty Sieges, convinced him, that Flanks perpendicular to the Courtains, were of little Durance: And he wonders that the Reputation given to the *Hollanders*, for their Perfection in the *Art of Fortification*, ſhould be ſo great, ſince the Places fortified according to their Method make ſo little Reſiſtance; and for that there is not one that is well defended from the Cannon: Nevertheleſs, we may preſume to ſay, that Monſieur *Pagan*'s Method is not altogether without Defects; for the Enemy may batter a Flank ſo diſpoſed, before he comes upon the Covert-way: Therefore, to make the beſt of all Advantages which both the one and the other pcoduces in his Defence, Monſieur *Vauban* allows an Overture to this Angle, from 98 Degrees to 106, as may be ſeen, Book IV. C. 1. Sect. 3. For by this Means the Embraſures made in the Parapet in this Flank, perfectly uncover the Moat and the Covert-way. And though Monſieur *Vauban* ſhould not have made this Flank in a crooked Line, by Means of the Orillon and the retired Flank, however it ought to be preferred before others; becauſe the Ravelin covers the Overture which is allowed it above the Perpendiculars to the Courtain, and conſequently it is not too much expoſed; beſides that it conſiderably enlarges and diminiſhes the Faces, which are the largeſt Parts of a Fortification.

CHAP.

CHAP. II.

Of the Flank.

HERE we muſt repeat what we have already ſaid, That though the largeſt Flanks are the beſt, nevertheleſs it is a Thing diſputed among the Engineers, *Morſheuſer* made the Flank to a Square of 16 Fathoms; to a V, of 18; to a VI, of 20; to a VII, of 22; to an VIII, as far as a *Dodecagon* of 24. *Freittag* made it to a Square of 12; to a V, of 14; to a VI, of 16; to a VII, of 18; to an VIII, of 20; to a IX, of 22; to X, of 24; which Length he retains alſo in *Polygons* of 11 and 12 Baſtions. *Goldman* made it a Square of 12; to a V, of 16; to a VI, of 18; to a VII, of 20; to an VIII, of 22; to a IX, till he came to *Polygons* of 12 Baſtions of 24 Fathoms. In general, the *Hollanders* make their Flanks to a Square of 16 Fathoms, 2 Feet; to a V, of 18 Fathoms, 2 Feet; to a VI, of 19 Fathoms, 2 Feet; to a VII, 19 Fathoms, 5 Feet; to an VIII, 22 Fathoms, 1 Foot; to a IX, of 22 Fathoms, 1 Foot and a half; to a X, 23 Fathoms, 2 Feet; to a XI, of 24 Fathoms, 2 Feet. Monſieur the Count of *Pagan* allows the Flank in a Square, 19 Fathoms, 1 Foot; to a V, 24, *&c.* as you may ſee, Lib. 3. Chap. 16. and 17.

CHAP. III.

Of the Faces.

AS the Face is the moſt dangerous Part of Fortreſs, and for that it is extremely expoſed to the View of the Enemy, it is requiſite that it ſhould be as ſhort as may be; for that, by how much it is the more advanced towards thr Field, by ſo much it is the more liable to be attacked. Whence it comes to paſs that the Enemy of late generally makes choice of that Part to begin his Breaches. As to the Length of the Faces, the Engineers differ as much one among another, as they do about the Flanks. *Adrian Metins* would have the Face to carry two third Parts of the Courtain. Monſieur, the Count of *Pagan*, allows it in a Square fifty-five Fathoms, and permits the ſame Length for the Polygons. *Freittag* would have the Face to be always forty-eight Fathoms, according to the Practice of all the *Hollanders*. As for the Length of the Faces, after *Vauban*'s Method, ſee Chap. 16. of the third Book.

CHAP. IV.

Of the Orillon, and Flank retired; together with the Briſure, or Place where the great Guns are to be planted.

AS for what concerns the erecting of the Orillon, and Flank retired, according to Monſieur *de Vauban*'s Method, there needs no more

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han to read what he has written thereupon, in the ſecond Chapter of his third Book. But here is a ew Method; which though it is not better, however it is as good.

1. After the Out-lines of the Fortreſs are drawn, divide the Flank of one of the Baſtions into three equal Parts, and the Face of the oppoſite Baſtion into two, as A B, B C.

2. Draw from the Point B, which makes the middle of the Face, a Line through the third Part of the Flank, which is the neareſt to the Angle of the Shoulder D, prolonged in the Body of the Baſtion of five Fathoms, as D E.

3. Divide the ſame third Part of the Flank into two equal Parts; as F G and G D, from which Point G, erect a Perpendicular of about two Fathoms, as G H. Laſtly, Set the Compaſs upon the Point H, and ſo draw the Rounding of the Orillon, joining F D together.

4. Draw from the re-entering Angle of the Moat P, a right Line through the Angle of the Courtain L, prolonged in the Body of the Place, of an equal Bigneſs to the Line D E, that is to ſay, of five Fathoms, as K I; to the end that you may have the Briſure, where you may place the Piece of Cannon that points towards the Half-Moon, and cannot be battered from the Field; becauſe it is, as it were, covered by the Ravelin. Laſtly, To make the Rounding of the Flank retired, take the Diſtance K E, between the Points of the Compaſs, and make Sections toward the Moat, in L; from whence afterwards draw the Arch from K to F.

It cannot be ſaid, but that theſe Orillons are very good; for theſe Roundings give leſs Advantage to the Enemy's Cannon, and enlarge the

Room, as well for placing the Cannon, as for the Muſketeers. If you object, That the Diſtance from that Part where the Enemy may paſs the Moat, is too great; I anſwer, That the principal Defence of the ſmall Shot to hinder the Paſſage of the Moat, conſiſts in the Tenail; where you may ſet a Body of Muſketeers to fire continually.

Upon this Method, Monſieur *de Clermont* obſerves, That the Orillon of the Square would be too little, if you allow it no more than the third Part of the Flank, as to the Polygons; and therefore he requires two fifth Parts of the ſame Flank for the Orillon. See the Plate P, Fig. XXII. at the End of the third Book.

CHAP. V.

Of the Courtain.

IN regard the Courtain ought to cover the greateſt Part of a Work, it is requiſite that it ſhould be of a reaſonable Length; that is to ſay, that it ſhould never be ſhorter than ſixty Fathoms, and never longer than an hundred. *Morſheuſer* allows it ſeventy-two Fathoms; and *Freittag* as much. *Goldman* would have the Length to be of ninety-ſix Fathoms; *Anthony de Ville* 100. *Tieu* makes it ſeventy-four Fathoms in Length; *Himſel* eighty-four. Monſieur *de Clermont* allows it three fifth Parts of a Polygon; the Count *de Pagan* ſixty Fathoms. Monſieur *de Vauban* forms it according to the Plurality of the Baſtions: As you may ſee, Lib. 3. Chap. 17.

As to the Figure of the Courtains, there are ſome Engineers, who will have them to be as is marked at the Letter A; of which the Conſtruction is ſuch. See the Plate P, Fig. XXII. at the End of the third Book.

1. Divide the Line A B into five equal Parts, as A D, D M, N C, and C B, and take one for the Demi-Gorge, as B C, A D.

2. Divide the ſame Line A B into three equal Parts, and take one for the Capital, as B E, A F.

3. Where theſe three Parts are marked, as at R and G, bring down from the Points R G, two Perpendiculars, of which let each have the third Part of the capital Line for its Length, as R H and G I, and then join H and I together by a right Line.

4. Make upon the Points D and C, the Angle of the Courtain of 100 Degrees, and allow to the Flank the Length of the Demi-Gorge, as D P and C Q. This being done, join E Q and D P together to have the Faces. The Defects of the Courtain are, 1. That it is too ſhort. 2. That the Fortification takes up too much Room. 3. That it renders the Baſtion too acute.

Others there are that form an Angle withoutſide, as that which is marked with the Letter B. The Conſtruction of which is after this Manner:

1. Divide the Line AB into five equal Parts, as AC, CD, DE, EF, and F B.

2. Divide the firſt Line A B into three equal Parts, and allow one for the Capital, as A I, and BK; then join H I and B K together, to gain the Faces.

3. Divide the Courtain C F into two equal Parts, and upon the Middle, marked with the Letter L, erect a Perpendicular; which has the half of the Face G K; as L M.

4. Draw from C F two ſtreight Lines to the Point M, and your Courtain will be made. See the Plate P, Fig. XXIV.

Others make the Courtain of a circular Figure withinſide, like that which is marked C: The Conſtruction of which is as follows. See the ſame Plate, Fig. XXV.

Having obſerved what has been ſaid touching the three firſt Points of the preceding Courtain, take the Extremities of the Courtain B C, and make two Arches to croſs or cut one another underneath; and from this Point of the Interſection draw an Arch from one End of the Courtain to the other.

Laſtly, There are others that form the Courtain of a circular Figure withoutſide, like that which is marked D. The Conſtruction of which is like to that which we have already deſcribed, only that here you make the Interſection above the Courtain in E: From which Point you afterwards draw the Arch from one End of the Courtain to the other.

The Breaſt Courtains are thoſe which are drawn ſtreight out-right from one Flank to another. See the ſame Plate P, at the End of the third Book, Fig. XXVI.

CHAP. VI.

Of the Parapet.

IN regard that this Work is raiſed to cover the Cannon and the Soldiers which defend the Place, it muſt be allowed a reaſonable Height and Breadth. *Cellarius* allows it ſix Feet in Height, with a Foot of ſloping within Side; to the end the Soldiers may be able to ſtand the better when the Parapet is reared after that Manner. The Height withoutſide from the Cordon ought not to be above four Feet, becauſe the ſloping which is made by thoſe different Heights, inward and outward, gives the Soldier an eaſy View of the Covert-ways, and the Moats that are before him. As for the Thickneſs of the Parapet, Monſieur *Clermont* allows it for the Baſis, the third Part of the Baſis of the Rampart. The Count *de Pagan* makes it three Fathoms broad. Of which Opinion are ſeveral others, as *Goldman*, *Freittag*, and Monſieur *Vauban* himſelf. So that we may boldly ſay, That the Thickneſs of the Parapet is good, when it is not leſs than eighteen Feet, nor broader than twenty-four. For being weaker, the Parapet cannot long reſiſt the Force of the great Shot, which would ſoon level it with the Earth; and being thicker, it would hinder the Soldiers from the Sight of the Moat and the Covert-way.

If you would line the Parapet, it muſt be allowed a little Sloping, that the Soldiers may have the better Footing. The beſt Lining of Parapets is with Turf. As for the Earth or Mould which you are to make uſe of in erecting a Parapet, it is very requiſite to mix it with Withy Twigs, or Brambles, and to ſow it with any Weeds that take a deep Root, to bind the Earth together, ſo that the Cannon may not eaſily crumble it down. Hay of *Burgundy* is alſo very good for this Purpoſe, in regard that there is no Plant that puts forth more or deeper Roots.

CHAP. VII.

Of the Banquets.

AT the Foot of the Parapet, upon the Platform are uſually made two little Steps or ſmal Banks, of which the firſt is about two Feet broad *Goldman* makes it four Feet, *Freittag* three, th Count of *Pagan* two, Monſieur *Clermont* the ſame and one Foot, and one Foot and a half high wherein they all agree. There are two made, fo that the Soldiers are not all of an equal Height. S that the low Men are placed upon the upper Ste or Bank next the Parapet, and the taller upon th lowermoſt. So that every one may have a Vie from the Parapet, and Diſcharge at his Eaſe.

CHAP. VIII.

Of the Rampart.

THIS Work is the principal Piece of a Fortification; and therefore the Rampart ought t be higher and broader than any of the reſt of th Parts. *Fournier* allows from the Breadth of th Rampart from fifteen to twenty-five Paces; and fo the Height, from the Level of the Field from fifteen to twenty-five Feet. *Freittag* takes for th Baſe of a Square nine Fathoms; of a Pentagon ten; of a Hexagon eleven; of a Heptagon twelve; of an Octagon thirteen; of an Enneagon fourteen; and obſerves this Breadth in all other Polygons. The Height of the Rampart he thinks ſufficient i it be but three Fathoms; and he raiſes the ſaid Rampart above the Level of the Field three Fathoms. Monſieur *Clermont* would have the fourth Part of the Face allowed for the Baſe of the Rampart, or in the Field from eight to twelve Fathoms; believing that a larger Breadth would not only be uſeleſs, but alſo prejudicial, by reaſon of the great Space of ground it would take up, and the vaſt Quantity of Earth it would require. Monſieur *de Vauban* never makes the Baſis larger than eleven Fathoms, alledging the ſame Reaſon that Monſieur *Clermont* brings. The Height of this Rampart never exceeds four Fathoms, whether to cover the Houſes of the Place, or to command the Enemy's Approaches: For being lower, the Garriſon within could never command the Enemy's Works. If they tell me that in ſome Places a higher Rampart is requiſite; I anſwer, That a good Cavalier ſupplies that Defect, without raiſing the whole Rampart any higher. The upper Breadth of the Rampart ought to be from four to ſix Fathoms; for being too narrow, it would require that the Parapet ſhould be made too broad to conſume the reſt of the Earth appointed for the Rampart; beſides, that it would be prejudicial, becauſe too broad a Parapet hinders the Soldiers fram the Sight of the Moat; and being too large, the Remainder of the Earth would not ſuffice to make a good Parapet, which is alſo very dangerous. As for the ſloping of the Rampart, it has been ſaid above, That there ought to be allowed to the *Talus*, or ſloping of the Rampart, as the Earth tumbling down from the Top to the Bottom takes up of itſelf. For every Body knows, that, according to the Badneſs of the Earth, the ſloping ought to be more or leſs, the better to ſuſtain the Rampart. The beſt Earth is that which is called gray Clay, next to that the ſlimy Earth, becauſe that by reaſon of their Clamminess, they better reſiſt the Inconveniencies of Heat and Rain; beſides they bind exactly well together, ſupport themſelves with little ſloping, and feed the Roots of Weeds and Graſs better. To every Foot of Earth where the Rampart is raiſed, two Branches of Willow are to be ſet no bigger than a Man's Thumb: Beſides that, the Earth is to be ſo hard rammed down, that it may ſink four or five Inches, and that there remain not above ſeven or eight. Laſtly, You ought to ſow with Hay-Seed and Weeds upon the outſide in every Row, to the end the Earth may intermix with the Roots. Nor is there any Herb that caſts forth more or deeper Roots than the *Spaniſh* Trefoyle, or winged Clover. Moreover, you ought to erect the Platform ſo, that the Plane of it may decline ſomewhat towards the City, to carry off the Water. When you plant Trees upon the Rampart, it is a great Ornament in Time of Peace, and a good Proviſion in Time of War. There are ſome Engineers that do not like this Advice; for they ſay that the Wind makes ſuch a Noiſe, when the Branches hit one againſt another, that the Men can hardly hear one another: Beſides that, it is a great Hindrance to the Centinel, which is a Conſideration not altogether to be rejected. Laſtly, we cannot paſs by in Silence the Fancy of ſome Men, who proportion the Thickneſs of the Rampart to the Number of the Baſtions of the Fortification; as if a Hexagon ought not to have as good a Rampart as a Decagon. I would fain aſk them, Whether ſmall Places are not attacked with the ſame Arms as great ones? If they anſwer, That there is more Earth taken out of the Moat of a large Place, than a ſmall one; we reply, That it may be ſpent upon the Glacis: For that the larger the Glacis's are, the better they are.

CHAP. IX.

Of the Embraſures and Merlons.

MANY have propoſed ſeveral Sorts of Embraſures, but the beſt are thoſe which are ſtreight and narrow withinſide, and wide towards the Field; to the end that the great Guns may play with more Eaſe toward the Right and Left. The Merlons, to the end that they may be good, ought to be made of Earth, the moſt eaſy to be tempered that may be: And this Earth ought alſo to be mixed with Withy Twigs, or Brambles, provided they take Root, after which they are to be lined with good Turf.

CHAP. X.

Of the Moat in the Body of the Place.

IN regard that every Fortreſs ought to be environed with a Moat, we ſhall briefly examine which Sort of Moats are firſt to be preferred. Some make them broad, others narrow; one draws the Moat parallel to the Faces, another draws them narrower toward the Point of the Baſtion, than in any other Places. Laſtly, one is for a dry Ditch, another for a Moat that is full of Water. One prefers a Moat very deep, but not ſo broad; another would have it broad, but not ſo deep. Let us examine every one of theſe in order. The Coun of *Pagan* makes his Moat for a Tetragon ſixteen Fathoms broad; and for Polygons of twenty, hi Depth does not exceed four Fathoms. Monſieu *Clermont* takes from ſixteen to twenty Fathoms, fo the Breadth of the Moat, without any regard t the Plurality of Baſtions, and makes it hollow from eighteen to twenty Feet. *Fournier* would have i broad from fifteen to twenty-five Paces, and dee from fifteen to twenty-five Feet. *Cellarius* make his Moat three Fathoms deep, and broad at the To about nineteen, and at the Bottom near thirteen Monſieur *de Vauban* prefers Monſieur *Clermont'* Way before all the reſt, as to the Breadth and Dept of the Moat: For as to the Way of drawing ou the Moat, Monſieur *Clermont* makes it narrowe toward the Point of the Baſtion than toward th other Parts; more eſpecially if the Flanks are large for he ſays, that otherwiſe, it would be requiſit that the Moat ſhould be as large as the Length o the Flank, or elſe much narrower; and in the firſ caſe there would be a Neceſſity of making it ver ſhallow, which would render it defective, for tha the Enemy would eaſily ſhoulder himſelf into it And ſuppoſing it were of a reaſonable Depth; ther would be Ground which no Body would kno what to do with, by reaſon of the extraordinar Wideneſs. And in the ſecond Caſe, there woul be one Side of the Flank that would not uncove the Moat, which would be againſt the Rule of Fortification. Others anſwer firſt, that i

th

the Moat were as large as the Flank, with a moderate Depth, that Wideneſs would hinder the Enemy from croſſing the Moat, without great Loſs of his Men. But if the Depth were a little more than ordinary; and it ſhould be aſked, what ſhould be done with the Earth taken out of the Moat? they reply, it would make the Glacis. The Learned may judge as they pleaſe; but for my part, I hold with them that are for making the Moat parallel to the Line of Defence. If they ſtill object, That the Rounding of the Moat being as large as in other Places, all the whole Courtain and Face of the oppoſite Baſtion cannot be diſcovered; we muſt anſwer, that if they would uncover thoſe Parts above the Rounding, they ought to make no Moat at all, becauſe the Point of the Baſtion itſelf is not proper for that. Add to this, that if the Moat be made narrower toward the Point of the Baſtion, the Enemy having once gained the Point, the Earth of which filled one Part of the Moat, he will eaſily paſs it by, throwing Bavins over the Ruins of the Baſtions, which will ſhew him, as I may ſo ſay, the Way to enter directly into the Baſtion.

The next Queſtion is, whether a Moat full of Water is to be preferred before a dry Moat? which a Diſtinction between the great and ſmall Places will quickly decide. As for great Fortreſſes, it cannot be denied but that dry Moats are to be preferred before thoſe full of Water. Some will object, That a Moat full of Water ſecures a Place againſt Scaladoes and Surprizes; beſides that, is very hard to be filled up; and that it affords great Trouble to the Enemy, that would either paſs it, or cover himſelf, or fight within it: And that on the other Side, beſides that a dry Ditch is extremely expoſed to Surprizes, very eaſy to be filled up, and no leſs eaſy to be paſſed; it is very proper to cover the Enemy in making of Mines, by Means of which he may blow up a great Part of the Place. But I anſwer to this, that as well a Moat full of Water hinders the Sallies of thoſe within, without the Help of Boats, which make ſo great a Noiſe, that it is impoſſible but the Out-Centinels near the Place beſieged, muſt hear it; and the ſame that is to be ſaid of the Sallies, is to be ſaid of the Retreats. Beſide, if the Water that fills the Moat be not a running Stream, it begets an unwholſome Air, cauſes frequent Diſtempers, and renders the Soldiers leſs courageous, by reaſon of the noiſome Stenches that ariſe out of it; and on the other Side, beſides that, a dry Moat is more commodious for Sallies, and ſafe Retreats; there is no Fear of Sickneſs proceeding from noiſome Water, and unwholſome Air. To ſay ſomething of the Convenience of Mines, which the Enemy has to make, you muſt make a Cuvette, or a little Dike in the Middle of the Moat, from fifteen to twenty Feet broad, and very deep; for the deeper it is, the better it is: Surround it with a good Parapet with Paliſadoes round about; and ſo you will be ſecure from Mines and Surprizes. As for little Fortreſſes, a Moat full of Water is better than a dry, becauſe Sallies, Retreats, and Succours, are not ſo neceſſary as in great Places. The Moat is alſo to be rounded before the Point of the Baſtion, to the end that it may be of the ſame Wideneſs quite through, and that it may not advance too far into the Field; which it would do if it were pointed. You may alſo ſet a *Corps de Gard* upon this Rounding, the better to defend the Covert-way. Laſtly, When you would line the Moat, they never allow it any great Talus or Sloping; only they allow it ſuch as the Earth of the Rampart, and the Moat gives it of itſelf.

CHAP. XI.

Of the Moat belonging to the Outer-Works, and the Avant-Moat.

THE Moat, belonging to Outer-Works ought to be neither ſo great, nor ſo deep, as that which belongs to the Body of the Place: For a Wideneſs of twelve Fathoms ſuffices for theſe Moats, being hollow from twelve to fifteen Feet.

In ſhort, there are ſome Engineers, who make a little Moat about the Glacis, though others practiſe quite contrary. The firſt pretend that the Earth taken out of the Moat, ſerves to fortify the Glacis, and ſecure the Covert-way. On the other Side it is ſaid, that the Avant-Moat ſerves only to hinder the Sallies and Retreats of the Garriſon: And this Reaſon prevails; for if you have need of Earth, the better to ſecure your Covert-way, you may make the Moat of the Body of the Place deep, and employ the Earth which you take from thence, for that Purpoſe. If you think that this Moat prevents Surprizes, and the Approaches of the Enemy; I anſwer, That a good wide Glacis will do the ſame, without being at ſo much Charge for an Avant-Moat. Nevertheleſs, ſometimes they are conſtrained to environ the Glacis with ſuch a Moat:

They make it five Fathoms wide, and two deep. Such a Moat as this you may ſee about the Citadel of *Straſburgh*.

CHAP. XII.

Of the Covert-way, and of the Glacis.

A GOOD Covert-way will require at leaſt five Fathoms in Breadth, eſpecially if the Ground will permit it; for one broader is uſeleſs and prejudicial, unleſs its Parapet be higher than ordinary; otherwiſe it is eaſily pierced by the Enemy's Batteries: And one leſs wide, is defective in this, that there is not room for the great Guns and Men, but one will hinder the other. Beſides that, when it is too narrow, it is not flanked on ſo many Parts as it ought; and it may be ſaid, that this Part muſt be then too much in View of the Enemy, whoſe chiefeſt Effort in a Siege it is, to make himſelf Maſter of the Covert-way.

This Covert-way has no other Security than the Glacis, which ſerves it for a Parapet round about. The Wideneſs of it ought to be at leaſt from thirty-ſix to forty Fathoms, loſing itſelf inſenſibly in its Inclination towards the Field. But the better to ſecure the Covert-way, we muſt ſay, that the largeſt Glacis's are the beſt; for that by this Means, the Enemy lies more open; and the leſs it has of Slopings, the better they are, becauſe the ſmall Shot is the more ſecure in the Covert-way, and does more Execution. In ſhort, there is nothing to be ſuffered about the Glacis, that may favour the Enemy in his Approaches: So that if the Glacis be higher than five Feet above the Covert-way, you muſt put one or two Banquets below, as need ſhall require, for the ſhort ſtatured Soldiers.

CHAP. XIII.

Of falſe Brays.

HERE it is, that ſome will aſk me why the *French* admit no falſe Brays in their Fortifications, as being a ſecond Defence, and an admirable Work to diſpute the Counterſcarp with the Enemy, and to hinder him from croſſing the Moat. Moteover it is certain, that ſmall Shot does more Execution from a low than an high Place. Beſides, that the ſmall Shot placed in the falſe Bray, doubles the Defence of it, as that Work doubles the Defence of the Place. But if you talk of the Defence, Why do you then put the Counterſcarp before the Faces, knowing that thoſe Parts defend nothing? You will anſwer, That this is to diſpute the Paſſage of the Moat. But conſider, that the Enemy having broken the Parapet of the Point, may afterwards pierce with his great Guns the Walk that runs all along the Face: Beſides that, the ruining of that Work is very advantageous to the Enemy, who would willingly have wherewithal to fill the Moat. As for the part of the falſe Bray that is before the Courtain, it is no longer good; becauſe it does not flank the Faces of the Baſtions, nor hinder the Paſſage of the Moat, which is objected always for the principal Reaſon. Nevertheleſs the Remainder of that Work, which is before the Flank, will be good: But know that this Part is eaſily rendered unſerviceable, by the Ruin of the Rampart, and the Parapet of the Flank, which falling withinſide, fills up its Platform: And if the Rampart be lined, the Splinters of it maim the Soldiers that guard the Flank of the falſe Bray. To remedy which Defects, the *French* now-a-days erect Tenails in the Moat before the Courtain, and before the Flanks ſeparated from the Body of the Place, by a little Moat, to the end the Fall of the Rampart of the Body of the Place may not kill or wound thoſe that are in it, being lined with Walls. There is nothing of all that you talk of falſe Brays, that can be attributed to theſe Tenails; beſides, that they caſt not the half of what thoſe other Works do.

CHAP. XIV.

Of Cavaliers.

CAvaliers are one of the beſt Defences of a Place, becauſe they moſt notably ſcour the Field, which obliges the Enemy to open his Trenches at a great Diſtance, in regard theſe are as ſo many ſecond Baſtions, which are oppoſed to the Enemy. And moreover, that they defend the Paſſage of the Moat, command the Covert-way, and above the Glacis; it is certain, that being well diſpoſed, they may defend the Head of the Breach, which the Enemy ſhall make in the Face of the Baſtion, wherein thoſe Cavaliers are erected,

erected. Now in regard that Opinions are different, as well in reſpect of the Place where they are to be ſet, as in regard of their Figure, let us ſee the Reaſons both of the one and the other.

I. There are ſome that would have the Cavaliers placed upon that Part of the Courtain, which diſcovers the Face of the oppoſite Baſtion; that is to ſay, upon the Lines of the ſecond Flank, as A; the Conſtruction of which is ſuch. See the Plate Q. Fig. XXVII.

1. Bring down a ſtreight Line perpendicularly under the Flank, and upon this Line put two third Parts of the Demi-Gorge, as A B.

2. Divide the Line A B into two equal Parts, as AC, C B, and prolong perpendicularly the Point C, till this Prolongation be equal to the Demi-Gorge, as C D.

3. Bring down alſo a Perpendicular from the Point D, of the Length C B, as D E; and at length join B E together by a right Line.

4. Having raiſed the Cavalier to a juſt Height, they give it a Parapet of three Fathoms, and two Banquets, as is uſual.

1. But it may be objected againſt this Situation, That the Cavalier does not flank, but very obliquely; and by Conſequence, that the Effects of it are of little Conſequence.

2. That the Ruins which the Enemy's Cannon will make, as being oppoſed to it in Front, falling between the Courtain and the Cavalier, will hinder the Execution of the ſmall Shot of the ſecond Flank.

II. 1. Others

II. 1. Others lodge the Cavalier in the Middle of the Courtain, and give it a triangular Figure; alledging, That in that Part, one and the ſame Cavalier may flank two Faces of the Baſtions. To which it is anſwered, That a Cavalier cannot be erected after that Manner, but in Places which have more than half the Courtain for the ſecond Flank; which would be very difficult, unleſs it were in Cities where the Angles of the Polygon are of a very large Overture. For to ſay, we ought to make theſe ſecond Flanks very large, as well to augment the Firing from the Courtain, as to gain room for placing of the Cavalier; this is to make Baſtions in a Place, that ſerve for nothing; becauſe, that by this Means, the Flanks are made ſo ſmall, that they ſeem to be only for Ornament.

2. That the Enemy ſtands in no Fear of the Firing from a Cavalier diſpoſed after that Manner, when once he is lodged upon the Counterſcarps, becauſe it is too high, and the Cannon cannot plunge low enough.

The Conſtruction of this Cavalier is ſuch. See the Plate Q, Fig. XXVII. B.

1. From the Courtain let fall a perpendicular Line, and ſet off there above fourteen Fathoms; as AB.

2. Take that Diſtance, and draw from the Point B a Circle.

3. Divide this Circle into three equal Parts, beginning from the Point A; as, AC, AD, and CD; which join together by right Lines; and this ſhall be the Baſe of the Cavalier.

4. Draw on the Sides A C, and A D, the Baſe of the Parapet of three Fathoms. But it is to be obſerved, That theſe Cavaliers are not to be erected but from nine to ten Feet above the Platform of the Rampart, unleſs there be very ſtrong Reaſons to raiſe it higher. In the mean Time, it is very true, that this Cavalier is not better than the preceding, becauſe the Angles of it are very acute; for when the Angle A is carried away, all the reſt is worth nothing; ſince neither Cannon nor Soldiers can ſubſiſt upon the Side A C and A D, by reaſon of the Enemy's continual playing upon them.

III. Some raiſe the Cavaliers upon the Platform of the Baſtion, and diſpoſe it in ſuch a Manner, that the Faces and Flanks of the Cavalier are parallel to the Faces and Flanks of the Baſtion; as C. The Advantages that proceed from this Diſpoſition, are, that the Enemy being got upon the oppoſite Counterſcarp, will be troubled to lodge his Cannon there, by reaſon of the Cannon upon the Flank, and upon the Cavalier; which playing without ceaſing, will diſmount the Enemy's Artillery, and hinders him from raiſing Shoulderings to ſecure himſelf: Beſides that, the Breach of the oppoſite Face is much better defended, and the Field better ſcoured. But one would think they might enjoy all theſe Advantages without poſſeſſing the Platform of the Baſtion; and by that Means deprive themſelves of the Advantage of making Entrenchments; which favour the Defence of Aſſaults. Beſides that, theſe Cavaliers are of no uſe for the Defence of the Breach made in the Baſtions where they ſtand. And there is this moreover, That the Beſieger may at the ſame Time, with a Mine, carry away a Part of this Cavalier with the Face of the Baſtion. And laſtly, It is for the Defendants to deprive themſelves of ſeveral Advantages; which we ſhall obſerve in the following Method, and which has all the Advantages of the preceding Situations, without being obnoxious to their Inconveniencies. But before we ſpeak of this Cavalier, obſerve the Conſtruction of it; of which we have ſet down the Advantages and Diſadvantages.

1. If the Baſtion is empty, it ought to be filled up, till it come to be as high as the Platform.

2. Which being done, raiſe that which was empty upon the Platform, from nine to ten Feet.

3. Having levelled that Height toward the Top, you ſhall draw the Baſe of the Parapet of three Fathoms, which ought not to be raiſed above ſix Feet; becauſe the Cannon are not to be placed higher; for that being higher, they would require a Battery to be raiſed on Purpoſe.

IV. Laſtly, There are others that place the Cavalier within the Baſtion of a circular Figure, diſpoſing it thus:

1. They prolong a Line of Defence in the Body of the Place, till it cut the Radius from the Cente at the Point A.

2. They divide the Diſtance between this Poin A, and that of the Gorge B, into two equal Parts as, A C, C B.

3. From the Point C, they draw a Circle, whic makes the Baſe of the Cavalier.

4. They raiſe this Place from nine to ten Feet, above the Platform of the Baſtion.

5. They allow this Cavalier a Parapet three Fathoms wide, and one high.

6. The beſt Lining of this Cavalier, is with Turf; for if it were of Maſon's Work, the Bricks and Stones, which will be ſhattered from it, would annoy thoſe that defend the Rampart.

It is objected againſt this, That they do not leave room enough between the Foot of the Cavalier, and the Parapet of the Flank, for the free Paſſage of the Men that are to defend the Breach, and to traverſe the Guns, which are upon the Flanks of the Baſtion, becauſe their Carriages being long, they will take up a great deal of Ground.

But it is anſwered, That this Cavalier being diſtant, at leaſt, five Fathoms from the Parapet, this Paſſage ſeems to be more than ſufficient to communicate between the Rampart and the Baſtion, in reſpect of the Place of the Cannon; and in regard the Largeneſs of the Baſe of the Cavalier may be leſſened, if it be found to incommode the Paſſage, we muſt confeſs, there is Room enough, not only when the Cannon are mounted upon ſmall Carriages, but that when they are mounted upon their uſual Carriages, theſe Cavaliers bear them above all others.

CHAP. XV.

Of Counterſcarps.

IT may be ſaid, That Counterſcarps cut in the Rock, are the beſt; for, beſides the Difficulty of opening them, to deſcend into the Moat, they need no Talus or Sloping, as being ſufficient to ſupport themſelves.

Thoſe that are lined are to be preferred before thoſe that are not, by reaſon of their Durance; though it may be feared, That the Enemy will make uſe of that Lining to ſecure himſelf, and make a Gallery all along with Embraſures, to play upon thoſe that defend the Moat: But this Reaſon ſignifies little; for when a Moat is full of Water, the Counterſcarp ought to be lined of Neceſſity; otherwiſe the Earth, being moiſtened by the Water, tumbles eaſily down; but if the Moat be dry, a Lining is not ſo abſolutely neceſſary. The Sloping ought to be allowed after ſuch a Manner, that if the Enemy ſhould enter with the Soldiers of the Garriſon, upon ſome hot Occaſion, he could not eaſily get out again. That Part of the Counterſcarp which is before the Point of the Baſtion, ought to be rounded, to gain the Space above the Covert-way; provided you can keep there a Body of your Men, to be in a Condition to ſuſtain an Aſſault.

CHAP. XVI.

Of the Streets, Places of Arms, Corps de Gard, and Magazines.

HAving ſhewed, Book 3. Chap. XX. how to make the Streets in a Fortreſs, we ſhall firſt ſpeak of the Place of Arms. The grand Place of Arms ought to be in the Middle of the Fort; the Conſtruction of which is contained in

Chap. XX. Sect. 3. The leſſer Places of Arms ought to be on the Side of the Baſtions; the Bigneſs of which ought to be proportioned ſo, as to hold two hundred Men for every Baſtion; or five hundred, if they are to ſuſtain a Siege: And in regard that every Man marching in Battalia, takes up no more than three Feet in Rank, and ſeven in File, it is eaſy to know how many Men will ſerve for every Fortreſs, and how large the Places of Arms ought to be.

The moſt numerous Corps de Gard ought to be in thoſe Parts where the moſt numerous Guard mounts. There muſt be one or two Chimnies at leaſt; and a little Theatre of Wood all along, about three Feet high from the Ground, and ſeven or eight Feet broad, for the Soldiers to lie upon. The other Corps de Gard, built after the ſame Manner, are to be placed near the Gates, or Paſſages.

In regard that there is always Occaſion for Ammunition, that is, for Powder and Ball, for the Soldiers that are upon the Ramparts, there muſt be Arſenals near at hand. But great Care muſt be taken to put the Powder where it may not take Wet; much more, where it may be in Danger of being fired.

The Magazines of Hay and Provender for the Cavalry, ought to be near the Stables where the Horſes ſtand. The others muſt be built in the moſt ſecure Parts of the Garriſon.

In regard the Soldiers, as well Foot as Horſe, are often lodged in Hutts; theſe Hutts are to be ſet up near the Rampart, to the end, that in caſe of Neceſſity, they may be ready upon the Rampart, to defend the Place. To which Purpoſe, the Town is to furniſh them with Beds, Tables, Benches, and Hangings, for the Officers Chambers, under whoſe Government the Soldiers are to ſerve; their Preſence being neceſſary, to keep them in Order, and from being injurious to the People of the Town. Every Hutt ought to be ſo large as to hold four Soldiers. Every Captain ought to have a particular Chamber, and another for two Lieutenants. Theſe Hutts ought to be eighteen Fathoms long, and ſeven and a half broad, and four Fathoms high, though there are ſome that are higher.

CHAP. XVII.

Of the Gates.

A GATE, if it be well placed, ought to be in the Middle of the Courtain; becauſe that in that Part it is defended with two Flanks, which lie on both the Extremities of it. The Gate cannot be too well ſecured, becauſe that there Surprizes are generally moſt attempted; whether by petarding, or by Intelligence from the Garriſon. Some place the Gates in the Flanks, becauſe, ſay they, the Sallies are by that Means more private and for that thoſe Gates look athwart the oppoſite Flank. But, beſides that, being ſo placed they very much weaken the Flanks, which are almoſt the chief Strength of the Place, and hinder by that Means the oppoſite Face to that Flank from being well defended; they alſo hinder the Uſe of the retired Flanks and the Tenails.

As for thoſe that are placed in the Faces of the Baſtions, they are worſe diſpoſed; not only becauſe it is a kind of a Breach already made, but becauſe they are not flanked, but by a Part at a great Diſtance: The Sallies alſo are too much in View; nor can they be ſecured by any Work, but ſuch a one as is not flanked; which is a very great Defect.

The Wideneſs of the Gates ought to be from fourteen to ſixteen Feet. The Height from fifteen to ſeventeen. The Thickneſs like to that of the Rampart of the Wall. They ought to be all vaulted, or elſe the greateſt Part of them, and well guarded.

There muſt be great Stones laid at the Extremities of the Gates, to hinder the Carts from ſpoiling the Wall. The Wood of the Gate ought to be of good Oak, joined and faſtened with good Nails and ſtrong Bars of Iron.

CHAP. XVIII.

Of Back-Doors, or Sally-Ports, and Draw-Bridges.

TO ſally out of the falſe Brays, Sally-Ports are made of ſuch a Wideneſs that the Cannon may paſs through them; that is to ſay, they ought to be from ſeven to eight Feet wide, and from eight to nine Feet high.

The Draw-Bridges are made after ſeveral Faſhions; but the moſt uſual are made with Pliers. Their Length and their Wideneſs ought to be proportionable to their Borders or Frame of the

Gate which are to hold them, being drawn up. The Arms ought to be from eight to nine Inches thick, as alſo the Beam that joins them.

The Shoulder to which the Arms are annexed, and upon which they are to turn, ought to be from fourteen to ſixteen Inches in Diameter. The Extremities being bound about with two good Circles of Iron, you muſt drive through the Center two Iron Pins, a Foot long, and two or three Inches in Diameter, to the end that it may the more eaſily move upon a ſtrong Band of crooked Iron, which is to be joined to the Threſhold and Jaumbs, or Side-Poſts of the Gate. The Pliers are to be twice the Height of the Gate, at leaſt, and one Foot in Diameter. The inner Square muſt be traverſed with a St *Andrew*'s Croſs, which will ſerve for a Counterpoiſe. The Chains are to be of Braſs, to the end that the Bridge may never be let down without making a Noiſe.

CHAP. XIX.

Of Bridges.

THE Bridges of a Town are to be from fourteen to fifteen Feet wide; lower than the Field, and ſomewhat round. When they are ſtreight and even, they ought to be made a little higher in the Middle than toward the Extremities, that the Foot of the Gate may not be diſcovered. Though the Supporters of Bridges may be of Stone, nevertheleſs they will be better, if their Planks and Rails are of Wood, that they may be the more eaſily cut down upon Occaſion. When there is no Half-Moon before a Gate, it is certain that the Bridge which croſſes the Moat ought to be the wider, becauſe there muſt be a good Corps de Gard upon it, and a Draw-Bridge. But if there be a Half-Moon, ſome turn aſide the Way all along the Gorge of the Half-Moon above the Counterſcarp, and make a Corps de Gard and a Paliſadoe, which hinders the Entrance of the Enemy: Others carry the Way through the Extremities of the Face. And a good Corps de Gard ought to be ſet at the End of the Bridge with a Portcullis.

BOOK V.

CHAP. I.

IN regard that Fortification is either continual, or tranſitory, we ſhall now ſpeak of the latter, as having given full Inſtructions for the firſt: Let us begin with a Redoubt.

Of the raiſing a Redoubt.

1. Make a Rectangle Square, each Side of which contains from twelve to twenty Fathoms.

2. Within this Square draw the Baſe of the Rampart three Fathoms large; and that of the Parapet from nine to ten Feet. The Height of the Rampart above the Level of the Field ought to be three Feet; and that of the Parapet above the Platform of the Rampart, of five, as is uſual: Or of ſeven, when there are two Steps or Banquets: Though ſometimes they raiſe the Rampart a little higher, as Neceſſity requires.

3. About the Rampart toward the Field draw another Parallel three Feet wide, which is called the Berme.

1. Above the Berme make a Moat of four Fathoms, with a Rounding before the Points of the exterior Sides: The Depth of the Moat ought to be about eight or ten Feet.

5. The Bridge for Entrance into the Redoubt ought to be ten or twelve Feet broad, when you would bring the Cannon into it; otherwiſe five or ſix Feet of Breadth will ſuffice. See the Plate Q, Fig. XXVIII. in Chap. XIV. Lib. IV.

CHAP. II.

Of the Half-Redoubt.

1. DRAW a Line of ſeventeen Fathoms, as AB.

2. Make an Iſoſceles Triangle of twelve Fathoms from the Points AB, as AC, CB, and join A C and C B together.

3. Prolong the Line A B, and place upon the Prolongation on each Side, eight Fathoms and three Feet, as A D, B E.

4. All the reſt is done, as in the precedent Work. See the Plate R, Fig. XXIX.

CHAP. III.

Of the Star-Square.

1. MAKE a Square, each Side containing twelve Fathoms in Length, as A B C D.

2. From the Middle of each exterior Side, draw a Perpendicular of two Fathoms, as DEFG; and afterwards draw AB in the Point E, BC in the Point F, DC in the Point G, and DA in the Point H. The reſt is done, as in the Redoubt. See the Plate R, Fig. XXX.

CHAP. IV.

Of the Star-Pentagon.

1. DRAW a Circle of twenty-ſeven Fathoms, and divide it into five equal Parts, with thirty-one Fathoms five Feet, as A, B, C, D, E.

2. Join the Sides together by ſtreight Lines, and divide each into two equal Parts; let fall from the Middle of them the Perpendiculars of five Fathoms, F, G, H, I, L.

3. Draw from the Points A, B, C, D, E, ſtreight Lines into the Points F, G, H, I, L.

4. The Baſe of the Rampart is ſix Fathoms, That of the Parapet two. The Berme three Feet. And the Breadth of the Moat five Fathoms. See Fig. XXXI. of the Plate R.

CHAP. V.

Of the Star-Hexagon.

1. DRAW a Circle of twelve Fathoms, and divide it into twelve equal Parts, as A B C D E F.

2. Join theſe Points together by ſtreight Lines, and divide each into two equal Parts, then let fall from the Middle a Perpendicular of two Fathoms, as G H, I K, M N.

3. Join theſe Points with the ſix firſt, as in the preceding Works.

4. Draw the Baſe of the Rampart of three Fathoms; that of the Parapet nine Feet; the Berme three Feet; and the Moat of five Fathoms. See the Plate R, Fig. XXXII.

CHAP. VI.

Of the Triangle of Half Baſtions.

1. MAKE an equilateral Triangle, of which each Side contains twenty-four Fathoms, as A B C.

2. Prolong the Side A B, and place upon the Prolongation eight Fathoms, as B E. Then alſo prolong the other Side B C, and place upon the Prolongation eight Fathoms C F. Laſtly, Place upon that of the Line C A the ſame Diſtance, as A G.

3. For the Demi-Gorges take the ſame Diſtance, as B H, C I, and A L, and then raiſe Perpendiculars upon the Points H, I, L. And for the Flanks a Length of four Fathoms H M, I N, and L O. This done, join the Points M E, O G, and N F together, to gain the Faces: And thus you have the Deſign of your Triangle.

4. The Baſe of the Rampart takes up three Fathoms and a half. The Baſe of the Parapet one Fathom four Feet. The Berme three Feet. The Moat five Fathoms. It ought to be parallel to the Flanks, and round before the Points of the Half Baſtion. See the Plate R, Fig. XXXIII.

CHAP. VII.

Of the Square of the Half Baſtions.

1. MAKE a Square, each Side containing twenty-four Fathoms, as A, B, C, D.

2. Prolong the Line B A, and upon the Prolongation place eight Fathoms, as AE: Then make that of the Line A D, of the ſame Diſtance as D F. This done, prolong alſo the Line D C o eight Fathoms, as C G: Then make the latter C of the ſame Length as B H.

3. For the Demi-Gorges, take alſo eight Fathom BM, AI, DK, and CL.

4. Raiſe upon the Points I, K, L, M, the Flank perpendicularly; the Length of which is four Fa thoms, as I, O, K, P, L, Q, and M, N.

5. Draw the Faces, joining together N H Q P F, and O E.

6. Having the Draught of the Square, let th reſt be as in the preceding Triangle. See the Pla S, Fig. 34.

CHAP. VIII.

Of the Square of entire Baſtions.

1. MAKE a Square, each Side containin thirty-one Fathoms, as A, B, C, D.

2. From the Middle of each Side, let fall a Pe pendicular of four Fathoms, as E, F, G, H.

3. Draw the Faces after *Vauban*'s Manner, a add thereto ten Fathoms.

4. Take the Extremities of the two Faces; a from one of them, let the Compaſs fall upon t Complement of the other; and in that Part where touches the Complement, join the ſame Point to t Extremity of the Face, which is the neareſt to for the Flank. That done, draw the Courtain.

5. The Baſe of the Rampart contains five Fa-homs, that of the Parapet two Fathoms three Feet, he Berme three Feet, and the Breadth of the Moat ix Fathoms. See the Plate S, Figure 35.

CHAP. IX.

Of a Pentagon with entire Baſtions.

1. DRAW a Circle of twenty-ſeven Fathoms, and divide it into five equal Parts, with ne Diſtance of thirty-one Fathoms five Feet, as A, B, C, D, E; and join the Points together by ight Lines.

2. From the Middle of each Side let fall a Per-endicular of five Fathoms, and draw the Faces as ſually, after *Vauban*'s Manner; the Length of hich muſt be ten Fathoms.

3. The Flank is made, by ſetting the two Points f the Compaſs upon the two Extremities of the aces; of which the one falls upon the Comple-nent of the Line of Defence, as has been ſaid in e preceding Chapter: This done, join the two lanks together for the Courtain.

4. The Baſe of the Rampart takes up five Fa-homs.

The Baſe of the Parapet two Fathoms three Feet.

5. The Berme of three Feet: The Breadth of e Moat ſix Fathoms. See the Plate S, Figure 6.

CHAP.

CHAP. X.

Of the Half-Hexagon with entire Baſtions.

1. DRAW a Circle of twenty-eight Fathoms four Feet, and divide it with the ſame Diſtance into ſix equal Parts, of which you ſhall tak three for your temporary Work.

2. Divide into two equal Parts each of the thre Sides, and from the Middle let fall a Perpendicula of five Fathoms.

3. Draw the Faces as uſually, of which let th Length be eight Fathoms.

4. The Flank and Courtain are made, as in th preceding Works.

5. The Baſe of the Rampart contains ſix Fathoms. The Baſe of the Parapet two Fathoms fou Feet. The Berme three Feet. The Breadth of th Moat ſix Fathoms. See the Plate S, Fig. 37.

A REMARK.

In regard this Fortification is only for preſen Uſe; and becauſe for that Reaſon it is ſometime ſtronger than the other, the Draught and Proportion of it could not be aſcertained, as in a continua regular Fortification. Only we may ſay, that mo frequently the Rampart of theſe Sorts of Forts i raiſed like thoſe of Redoubts. See the firſt Chapter, Lib. V.

CHAP. XI.

Of the Maxims of irregular Fortification.

IRregular Fortification is that, of which all the Sides and Angles are not equal one to another. The Original of this Fortification proceeds from ancient Towns and Cities; which were built after no regular Figure, and yet required to be encompaſſed with Walls and Baſtions to defend themſelves againſt the Aſſaults of their Enemies. But becauſe it was impoſſible to fortify thoſe irregular Places, and make them, in reſpect of their Duration, equal to regular Places, there are certain Maxims, according to which they may be environed with a paſſable Fortification. For Example:

1. Every irregular Fortification ought to be made according to the Maxims of the regular as near as may be.

2. The moſt irregular Forts are the beſt, provided they be not too eaſy of Acceſs.

3. Entire Baſtions are to be preferred as much as may be, before Half-Baſtions.

4. No Face ought to exceed ſixty Fathoms.

5. No Flank ought to be leſs than ſixteen Fathoms, if it be poſſible.

Therefore when you are to make an irregular Fortification, you muſt conſider, 1. The Quality of the Situation. 2. The Time allowed to make the Work. 3. The Number of Men which are to be put in to defend it. 4. The Number of Workmen. 5. The Victuals. After all you muſt draw the Plane, and fortify it after the following Manner.

CHAP.

C H A P. XII.

The Manner of fortifying an irregular Place, where there is nothing but the Field.

1. HAving the Plane of the irregular Place, divide each exterior Side into two equa Parts, and from the Middle let fall a Perpendicular

2. Upon each exterior Side draw an Iſoſceles Triangle of 480 Fathoms.

3. Place upon theſe Triangles all the Parts an Diſtances which you make uſe of in a regular Fortification, and take the Diſtances acroſs to put them upon the Parts of your irregular Plane. Eor Example: If an irregular Pentagon be to be fortified I take 180 Fathoms, and I make upon each exterior Side an Iſoſceles Triangle, A B C. Then I tak twenty-five Fathoms, which I put upon the Triangle A B C, as C D E; of which the Length D E ſhall be the true Length for the Perpendicular of th Line A B: Which done, I put fifty Fathoms upon the ſame Triangle, as C F G, the Length F G ſhall be the juſt Diſtance for the Face of my Work After this, I put again thirty-eight Fathoms thre Feet upon the Triangle; and the Diſtance taken acroſs H I, will give me the true Length for th Complement of the Line of Defence. Laſtly, join the Flanks and the Courtains together, as in regular. After which I divide the Flank into thre equal Parts; I draw the Briſure as uſually, and retain one of the three Parts of the divided Flank fo the Orillon, and the two others for the hollo Tower. See the Plate T, Fig. 38.

C H A P

CHAP. XIII.

Of the Body of the Place in an irregular Fortification.

THE Body of the Place make thus:

1. Take eleven Fathoms for the Baſe of the Rampart, and put them upon each Triangle. The Length acroſs will always give you the true Breadth of the Baſe of the Rampart.

2. Take three Fathoms, and bring them round about the Place, without putting them upon the Triangles. Draw the Banquets as uſually.

3. Take twenty Fathoms for the Breadth of the Moat, and put them upon all the Triangles, the Diſtance taken acroſs will be the true Breadth of the Moat for every Side. The Manner of making this Fortification is the ſame with that of the Regular. See the Plate T, Fig. 38.

CHAP. XIV.

To make a Half-Moon before theſe Fortifications.

BE ſure to ſee whether the Length of the Courtain exceeds 100 Fathoms or no. If it be from 100 to 140 Fathoms, take fifty Fathoms for the Capital of the Half-Moon or Ravelin. But if it be larger than 140 Fathoms, erect before the Ravelin another Work, whether a Horn or Crown-work. If the Courtain be not longer than 100 Fathoms, take the Half of the Courtain with the Briſure, for the Capital of the Ravelin, and the reſt is done as in a regular Fortification. For the Baſe of the Rampart is eight Fathoms. That of the Parapet three. The Breadth of the Moat twelve. Theſe Diſtances are to be put upon the Triangles, before the exterior Sides of which you intend to place the Ravelin, and afterwards taken acroſs.

CHAP. XV.

To ſet other exterior Works before the ſam Fortifications.

IF an exterior Polygon exceeds 120 Fathoms, and that you have ſtill room to erect a good Work before it, whether Horn or Crown-Work; as you may ſee in Fig. 39. which is a Crown-Work mad according to the Rules of Chap. 10. Lib. 3. The Parts of it ought all to be marked upon the Triangle

AB, Is the Baſis of the Rampart of the Ravelin, and the Horn-work.

CD, Is the Baſis of the Rampart of the Body o the Place.

EF, Is the Breadth of the Moat belonging t the Ravelin and Horn-work.

GH, Is the Perpendicular of the Horn-work from the End of which are drawn the Faces.

IK, Is the Breadth of the Moat belonging t the Body of the Place.

23, Is the Perpendicular of the Body of the Place

LM, Is the Face of the Horn-work.

NO, The Complement of the Line of Defenc to the Body of the Place.

PQ, The Face of the Body of the Place.

RS, The Capital of the Horn-work.

TV, the Diſtance which joins the Point of the Capital to the Horn-work.

WX, Are the Wings of the Horn-work.

CHAP. XVI.

How to fortify an irregular Place already built.

TO avoid much Labour, you muſt fortify the Parts of an old Fortification, and finiſh them, in the ſame Manner as they were begun, unleſs they are gone utterly to Decay; and then you may make what Alterations you pleaſe. To the End therefore, that Money may be laid out to good Purpoſe, when the Flanks are repaired, they muſt allow an Overture of 100 Degrees. If the Faces are tolerable, let them alone as they are, to avoid the vaſt Expence in making others. Whence it comes to paſs, that there is no ancient Place which is fortified after the *French* Manner, becauſe the Engineers have been always forced to labour uqon *Dutch* Fortifications. As for the Rampart and Parapet, they may be better fortified whatever Face they have. But to come to the Thing itſelf, let us obſerve the following Rules:

I. The exterior Side, the Length of which is from ſixty to eighty Fathoms, requires a Demi-Gorge from fourteen to fifteen Fathoms, and a Flank of fifteen Fathoms.

II. If the exterior Side takes up from 80 to 140 Fathoms, it is to be divided into five equal Parts; of which one is retained for the Demi-Gorge. The

Flank changes according to the Variety of the Sides. For Example: If the exterior Side is of 80 Fathoms, the Flank ſhall be of 16.

If of	The Flank of
90	17.
100	18.
105	19.
110	20.
115	21.
120	22.
125	23.
130	24.
135	25.
140	25 Fathoms 3 Feet.

This being well underſtood, it will not be difficult to reduce it into Practice. Suppoſe the Pentagon following, of which the Side A B is 130 Fathoms, B C 124, C D 130, D E 113 Fathoms three Feet, E A 146 Fathoms, and that you deſign to fortify it.

1. Allow the fifth Part of each exterior Side for the Demi-Gorges, as A F, B G, C I, C K, D L, D M, E N, E O, and A P.

2. Raiſe upon F G, H I, K L, M N, O P, Perpendiculars for the Flanks, in caſe you cannot allow them an Overture of 100 Degrees; the Length of which muſt be proportionable to the Length of the Sides. For Example: The Flanks F G ſhall have 24 Fathoms, H I 22, K L 24, M N 20, E A 25 Fathoms and three Feet.

3. In drawing the Line of Defence, you will have the Faces at the ſame Time.

4. The Baſe of the Rampart takes up eleven Fathoms. That of the Parapet three. The Breadth

of the Moat twenty Fathoms. The Covert-way and the Glacis, are made as is uſual. See the Plate W, Fig. 40.

OBSERVATION.

The Flank is left after the *Holland* Manner; that is to ſay, without either Orillon or hollow Tower, to avoid overmuch Expence.

III. If the exterior Side be from 140 to 170 Fathoms, the Flanks are allowed the following Length:

If it be 145, allow the Flank 25 Fathoms 3 Feet.
If 150, to the Flank 26 Fathoms.
If 155, to the Flank 6 Fathoms 3 Feet.
If 160, to the Flank 27 Fathoms.

IV. The exterior Side ſurpaſſing the Length of 160 Fathoms, to 280, is looked upon then as if it had two Sides; that is to ſay, that beſides the Baſtions which are placed upon the Angles there ſhould be a Platform in the Middle; as you ſee in Fig. 41. where the Side AB is 200 Fathoms, and the Conſtruction of it thus:

1. Divide the Side AB into two equal Parts; as AC, CB.
2. Divide either the Diſtance AC, or the other CB, into five equal Parts, to give one of them to the Demi-Gorge; as AD, EB, CF, CG.
3. Raiſe upon DG, FF, the Flanks of an Overture of 100 Degrees, the Length of which ſhall be the Demi-Gorge.
4. From the Point C, draw the Capital, which takes up the Length of the entire Gorge; as, CH.

Flank changes according to the Variety of the Sides. For Example: If the exterior Side is of 80 Fathoms, the Flank ſhall be of 16.

If of	90	The Flank of	17.
	100		18.
	105		19.
	110		20.
	115		21.
	120		22.
	125		23.
	130		24.
	135		25.
	140	the Flank of 25 Fathoms 3 Feet.	

This being well underſtood, it will not be difficult to reduce it into Practice. Suppoſe the Pentagon following, of which the Side A B is 130 Fathoms, B C 124, C D 130, D E 113 Fathoms three Feet, E A 146 Fathoms, and that you deſign to fortify it.

1. Allow the fifth Part of each exterior Side for the Demi-Gorges, as A F, B G, C I, C K, D L, D M, E N, E O, and A P.

2. Raiſe upon F G, H I, K L, M N, O P, Perpendiculars for the Flanks, in caſe you cannot allow them an Overture of 100 Degrees; the Length of which muſt be proportionable to the Length of the Sides. For Example: The Flanks F G ſhall have 24 Fathoms, H I 22, K L 24, M N 20, E A 25 Fathoms and three Feet.

3. In drawing the Line of Defence, you will have the Faces at the ſame Time.

4. The Baſe of the Rampart takes up eleven Fathoms. That of the Parapet three. The Breadth

of the Moat twenty Fathoms. The Covert-way and the Glacis, are made as is uſual. See the Plate W, Fig. 40.

OBSERVATION.

The Flank is left after the *Holland* Manner; that is to ſay, without either Orillon or hollow Tower, to avoid overmuch Expence.

III. If the exterior Side be from 140 to 170 Fathoms, the Flanks are allowed the following Length:

If it be 145, allow the Flank 25 Fathoms 3 Feet.
If 150, to the Flank 26 Fathoms.
If 155, to the Flank 6 Fathoms 3 Feet.
If 160, to the Flank 27 Fathoms.

IV. The exterior Side ſurpaſſing the Length of 160 Fathoms, to 280, is looked upon then as if it had two Sides; that is to ſay, that beſides the Baſtions which are placed upon the Angles there ſhould be a Platform in the Middle; as you ſee in Fig. 41. where the Side A B is 200 Fathoms, and the Conſtruction of it thus:

1. Divide the Side A B into two equal Parts; as A C, C B.
2. Divide either the Diſtance A C, or the other C B, into five equal Parts, to give one of them to the Demi-Gorge; as A D, E B, C F, C G.
3. Raiſe upon D G, F F, the Flanks of an Overture of 100 Degrees, the Length of which ſhall be the Demi-Gorge.
4. From the Point C, draw the Capital, which takes up the Length of the entire Gorge; as, C H.

5. Join the Extremities of the Flanks, and the Point H together, by a right Line, to gain the Faces. See the Plate W, Fig. 41.

OBSERVATION.

Theſe Sorts of Baſtions are perfectly well defended; for the Flanks of the neighbouring Baſtions play backwards upon their Faces; beſides that, almoſt all the Courtain ſerves them inſtead of a ſecond Flank, and very much augments their Defence.

V. The exterior Side ſurpaſſing 280 Fathoms, two flat Baſtions are placed there; holding this for a Maxim, That the greateſt Side ought to be 140 Fathoms.

CHAP. XVII.

How to fortify an acute Angle.

IF you find by chance an acute Angle with the Circuit of a Place which is to be fortified, ſince it is impoſſible to repair this Defect; becauſe you are obliged to make uſe of the old Ramparts; you are only to put upon this Angle a tenail Baſtion; which is thus erected:

1. Having made the Flanks, draw the Faces as the Line of Defence requires; but in regard they would be exceſſive long, and would form too acute a Point, that is corrected by putting forty Fathoms from the Top of the Flank above the Face, as A B, CD.

2. Join B D together by a right Line, and then divide that Line into two equal Parts, B E, E D; and from the Middle of the ſame Line, let fall a Perpendicular, which has for its Length the third Part of the ſame Line; as E F.

3. Draw the Points B D, in the Point F, by right Lines, and your Baſtion is made. Oft-times they erect little Ravelins before theſe Sorts of Baſtions: But to ſay the Truth, this Work is not worth any Thing; nor is it ever to be made uſe of, but upon Neceſſity. But you ſhall meet with it in ſome Places; as at *Geneva* and *Charlemont*. This ſmall Ravelin muſt not be ſeparated from the Baſtion, but by a ſmall Moat of five or ſix Fathoms. Moreover, there is no Neceſſity for its having Ramparts, but only a good Parapet Cannon Proof. There are ſeveral other Ways of fortifying an acute Angle; but which are of no more Value than this. Therefore we muſt endeavour to avoid them; for notwithſtanding all the Care a Man can take to fortify this Angle, it will be very defective. See the Plate W, Fig. 42.

CHAP. XVIII.

How to fortify a re-entering Angle.

THERE are few irregular Places, of which the old Encloſure does not form a re-entering Angle; which is almoſt always ſecure, as being ſeen from ſeveral Parts. But uſually it is accompanied with one Defect, that it almoſt always forms the two ſaliant Angles which are next it, too acute. It is true, that if theſe ſaliant Angles were not too acute, your Firing-place would be very great, from a Work made upon the re-entering Angle, to defend the Baſtians that are in Sight of it; nor is it always a Fault to have theſe re-entering Angles, which are thus fortified.

If the Angle be not very far ſunk in, and very obtuſe, as A, it is thus to be fortified:

1. Place on each Side of the Angle great Demi-Gorges, in caſe the Sides will permit it, and raiſe perpendicular Flanks, as large as you can.

2. Join their Extremities together, by a right Line; which you ſhall divide into two equal Parts; and from the Middle raiſe a Perpendicular, containg the Moiety of the ſaid Line.

3. Draw the Extremities of the Flanks toward the capital Line of that Perpendicular, and your re-entering Angle will be fortified. See Plate X, Fig. 43.

If the re-entering Angle be ſomewhat obtuſe, or ſtreight, in this Caſe, having taken good Demi-Gorges from every Side of the Angle, the Flanks are there to be raiſed; the Meeting of which forms the ſaliant Angle B; which is capable to defend the neighbouring Baſtions. See Plate X, Fig. 44.

⁂

CHAP.

CHAP. XIX.

Of the Artillery.

HAVING given ſome Account of irregular Fortification, reſerving to ourſelves another Time to ſpeak more of it; we ſhall only obſerve what Sort of Artillery they have in *France*. There is, 1. The Cannon, which is called the Battering Piece. 2. The Culverin. 3. The Falcon. 4. The Saker. 5. The Petard. 6. The ſmall Petard. The Battering Piece is ten Feet long, the Bullet about ſix Inches Diameter, and weighs thirty-three Pounds, requiring two Pounds of Powder, at leaſt, to charge it; and it carries directly forward 360 Fathoms. At the Diſtance of 100 Fathoms, it pierces two Fathoms of cloſed Earth. If it be not well ſettled, it pierces two Fathoms and a half; and if the Earth be poor and hungry, it pierces four Fathoms. You may diſcharge it eighty Times in a Day. The Dutch Cannon flings a Bullet of forty-eight Pounds, 400 Feet Diſtance, and pierces a Rampart of good and well-cloſed Earth twenty Feet deep. A half Piece of Battery carries a Bullet of twenty-four Pounds, at 300 Feet Diſtance, and enters twelve Feet of good Earth. The Falcon carries a twelve Pounder 200 Feet off, and enters ſeven Feet into a good Parapet.

A ſmall Petard cannot break a double Gate well barred.

A great Petard, fixed to a weak Gate, uſually makes no more than a Hole; and the greateſt Execution it can produce, is to break the fore Part of it.

There is nothing can ſtop the Execution of Mines, as they make them at preſent; nevertheleſs there muſt be a Proportion between the Petards, the Mines, *&c.* and the Powder.

Laſtly, a Muſquet carries 120 Fathoms, and if double charged 150, though it will kill a Man above 300 Paces. Diſcharged very near, it will pierce two Flanks two Fingers thick; but diſcharged at fifty Paces, it enters according to the Subſtance of the Body it meets with. We ſhall inſiſt no longer on theſe Things at this Time; intending to ſpeak more amply of them in another Treatiſe, where we ſhall ſhew the Manner how to attack a Place.

OF MILITARY ORDERS: OR, THE Embatteling and encamping of Soldiers.

Of embatteling of Soldiers.

B*Attails* are conſidered either in reſpect of the Number of Men, or in reſpect of the Form of the Ground. In reſpect of the Number of Men, it is either a *Square Battail*, a *Double Battail*, a *Battail* of the *Grand Front*, or a *Battail* of any *Proportion*, of the Number in *Rank*, to the Number in *File*. In reſpect of the Form of the Ground, the *Battail* is either a *geometrical Square* of Ground, or a *long Square* of Ground. For the Diſtance or Order of Soldiers martialled in Array, it is diſtinguiſhed either into *open Order*, which is when the Centers of their Places are ſeven Feet diſtant in Rank and File; or *cloſe Order*, which is when the Centers of their Places are 1 Foot $\frac{1}{2}$ diſtant both in Rank and File, or elſe three Feet $\frac{1}{2}$ in Rank, and ſeven Feet in File.

PROP.

PROP. I.

To order any Number of Soldiers into a Square Battail.

Suppoſe it were required to martial into a Square Battail 16129 Men; to do this *extract* the *Squar* *Root* of 16129, it gives 127, which is the Numbe of Men you muſt place both in Rank and File.

PROP. II.

To order any Number of Soldiers into a doubl Battail.

Admit 16928 Soldiers were to be martialled in double Battail, *extract* the *Square Root* of half th Number of Men, that is of 8464 it gives 92, an therefore, I ſay, that 92 Men muſt be placed i File, and 184 in Rank, which orders ſuch a Numbe of Men in double Battail.

PROP. III.

To order any Number of Soldiers into a Battail of th Grand Front.

Admit 16900 Soldiers were to be martialled in Battail of the Grand Front; *that is,* Quadruple or ſo that the Rank may be four Times the File *Extract* the *Square Root* of $\frac{1}{4}$ the Number of Me that is, of 4225, the Square Root of which is 6 the Number that muſt be placed in File, and fou Times 65, which is 260, is the Number to b placed in Rank, to form a Battail of the Gran Front.

PRO

PROP. IV.

Any Number of Men, with their Diſtance in Rank and File, being propounded, to order them iuto a Square Battail of Ground.

Admit 2500 Soldiers were to be martialled in a Square Battail of Ground, in ſuch Sort that their Diſtance in File ſhould be ſeven Feet, and in Rank three Feet, it is required to know how many Men muſt be placed in Rank, and how many in File. To draw up 2500 into a Square Battail of the Ground, *ſay*, as 7 to 3, ſo is 2500 to 1071, *&c.* whoſe Square Root is 32, the Number of Men to be placed in File. Now to find how many Men are to be placed in Rank, *divide* 2500 by 32, the Quotient is 78, which are the Number of Men to be placed in Rank, and four Men over and above to be diſpoſed of.

PROP. V.

Any Number of Soldiers propounded, to order them in Rank and File, according to the Reaſon of any two Numbers given.

Suppoſe 6400 Soldiers are to be martialled into Array, in ſuch Order that the Number of Men placed in File, ſhall bear ſuch Proportion of Men in Rank, as 7 to 13, ſay, as 7 to 13, ſo is 6400 to 11885, *&c.* whoſe Square Root is 109 *propè*, the Number of Men to be placed in Rank; by which divide 6400 it produces 58, *&c.* the Number of Men to be placed in File, and 78 Men to be employed elſewhere.

Of quartering and encamping of Soldiers.

In quartering and encamping of Soldiers, it is requiſite the *Quarter-Maſter-General*, and all othe under Quarter-Maſters, ſhould be ſkilled in Foo Meaſure, that ſo they may the better lay out thei Quarters as directed.

The common Allowance for the Depth of Ground that a Regiment of Horſe or Foot will take up, i proportioned after this Manner: The Wideneſ muſt be anſwerable to the Number of Men; ſuppoſe 200 Feet in Length be allowed for the Hutt for the common Soldiers, and 100 Feet for th Commanders and Suttlers Tents before them, eac Hutt is eight Feet ſquare, and holds two Soldiers the Diſtance betwixt each Hutt is two Feet, an therefore in the 200 Feet may ſtand twenty Hutts the Walk betwixt each Row of Hutts may b eight Feet, that is Hutt and Space left will b ſixteen Feet one Way, and ten the other Way; ſ that 200 Feet in Length, and 16 Feet in Breadth or 3200 Square Feet, will ſerve forty Men, and fo the 100 Feet more for the Officers there will b 1600 Feet; in all, 4800 Square Feet. Now fo 1000 Men, there muſt be twenty-five Rows o Hutts; ſo that a Regiment of Foot, containing 1000 Men, (beſides Officers and Suttlers) will take up 80000 Square Feet, and the Officers and Suttlers 40000 Square Feet more; that is, the whole Regiment, including Officers and Suttlers, will take up 120000 Square Feet, which is two Acres three Roods: But becauſe of Ways, there may be allowed three Acres of Ground for every Regiment, which may be 350 Feet deep, and 370 Feet wide, or near 360 Feet ſquare. Now if 1000 Men, Officers, Suttlers, Highways, and all take up a Square of 360 Feet, how many Feet ſhall the Side of a Square be wherein 10000 Men with their Officers and Suttlers may be encamped? Say as 1000 to 10000, ſo is the Square of 360, *viz.* 129600 to 1296000, the Square-Root of which is 1138 Feet, which Square contains very near thirty Acres of Ground.

For the Quartering of Horſe you muſt keep the ſame Depth of 300 Feet, as you did for the Foot, and take 200 Feet for the Hutts; the Hutt for one Horſe muſt be four Feet wide and ten Feet deep, ſo that twelve Horſes may ſtand together in a Hutt forty-eight Feet long and ten Feet deep, over and above there muſt be ſix Feet left for a Street, ſo the whole Depth is ſixteen Feet; the Hutts for the Troops will be ſix for twelve Troops; now conceive a Regiment to conſiſt of eight Troops, fifty to a Troop, it will take up, leaving twenty Feet, Streets and Croſs-ways, very near as much Ground as a Regiment of Foot, Ways and all muſt be allowed three Acres, that is, near 360 Feet Square, ſo that ten Regiments of Horſe will take up thirty Acres of Ground; moreover it will be needful, and you may very well allow as much Ground as both Horſe and Foot will take up, for the Train of Artillery, Victuallers, and Parade Places. From theſe Conſiderations, the young Beginners, nay, even the practiſed Soldiers, may receive Help, and thereby be enabled to encamp an Army, if required.

OF

OF

GUNNERY.

The Names of the chiefeſt Members of a Piece of Ordnance.

A CANNON is a long round Body either of Braſs or Iron, formed and made hollow by Art and Proportion; its Uſe is to offend afar off, with a Ball of Iron, Stone, or any artificial Subſtance, charged with Gun-powder in its Cylindrick Cavity, which being filled, in an Inſtant performs its Effect. This Machine was invented by an *Engliſhman*, and firſt put in Practice by the *Venetians* againſt the *Genoeſes* at *Chiezza*, Anno 1376.

The *Superficies* of the Metal is the outſide round about the Piece.

The *Body* is the Subſtance of the whole Maſs or Metal.

The *Chaſe* or *Soul* is the Cavity of the Piece in which they put the Charge.

The *Muzzel* is the Extremity of the Chaſe, at which you load and unload the Piece.

The *Calibre* is the Diameter of the Muzzel or Mouth, as A B.

The *Touch-hole* is that little Vent which paſſeth from the Convex Superficies to the Cavity of the Piece; it is made to give fire to the Powder within, as C; that which encloſeth the Extremity of the Chaſe, about the Touch-hole, is the Breech or Coyle.

The *Caſcabel* is the Pammel at the Breech or Coyle, as D.

The *Trunnions* are Pieces of Metal fixed unto the exterior Superficies of the Gun, and are thoſe on which it moves in the Carriage, as E E.

Malignions or *Dolphins* are two Handles which of late are fixed upon the Back of the Piece near upon the *Center* of *Gravity* thereof. Their Uſe is to mount and diſmount the Piece.

The *Body of the Piece* is that which is comprehended betwixt the Center of the Trunnions and the Caſcabel.

The *Vacant Cylinder* is comprehended betwixt the Center of the Trunnions and the Muzzel, as E B.

The *Freez* or *Muzzel Ring* is that thick Cornice which encompaſſeth the Convex Superficies of the Piece, as I; the *baſe Ring* is K L G; the *reinforced Ring* is M M; the *Trunnion Ring* is N N; and the *Corniſh Ring* is O O.

The *Line* of the *Cylinder* is a Line imagined to be drawn along the Chaſe, parallel to the Middle of the Chaſe, as X Z.

The *Line of Metal* is a Line touching the Top of the Cornice of the Baſe and Muzzel Rings, ſuch is the Line K E if it were drawn.

The *Diſpart Line* of the Piece is the Difference betwixt the Semi-Diameter of the Muzzel and Baſe Ring, as the Line I H.

The *Vent of the Piece* is the Difference betwixt the Diameter of the Shot and Mouth of the Piece.

The *Chamber* or *charged Cylinder* is that Part of the Chaſe toward the Touch-hole, equally large, nor narrower in one Place than in another, being that which contains the Powder and Ball.

A *Mortar-Piece* is a ſhort Piece, with which they ſhoot *Bombs*, *Granado-Shells*, *Stone-Balls*, &c. not by a right Line, or one nearly parallel to the Horizon; but by a Curve from on high, ſo that it may fall where it is deſired. Now this Mortar is placed in all reſpects as you ſee in Fig. 93. Plate IV.

Where A ſignifies the Carriage, B the Mortar, C the Courſe the Shot flies, and D the Place on which it falls.

Bombs are great hollow Balls of Iron or Braſs, in which are put fine ſifted Gun-Powder, which by a Fuſe, they proportion to them due Fire, that ſo they may break as ſoon as they fall amongſt the Enemy. Theſe *Fuſes* are ſmall Trunks of Wood, Tin, or Iron, filled with a Compoſition prepared for that Purpoſe.

Granadoes are of the ſame Form with *Bombs*, only ſmaller, and many Times are caſt by hand, being made of *Iron*, *Braſs*, *Glaſs*, or *Earth*.

A TABLE of the Dimenſions of the common *Engliſh* Ordnance.

Names of Pieces.	*Diameter Bore.*	*Len. Cha.*	*Powder Requi.*	*Bullets Diameter.*	*Greater Randoms.*	*Comp. Force.*	*Comp. Time.*
	Inch.	*Feet*	*Pound.*	*Inch.*	*Miles*		
A Rabbinet.	1.75	3	0.333	1.4	3.760	38	20589
A Falconet.	2.	4	0.580	2.1	4.398	61	14898
A Falcon.	2.75	6	1.646	2.6	4 797	166	5986
A Minion.	3.	8	2.612	2.8	5 864	238	5097
A Saker.	3.5	9	4.000	3 3	5 654	371	3152
A Demi-Culverin	4.5	10	7.347	4.3	4.886	733	1379
A Culverin.	5.	11	9.977	4.7	4 837	1000	1000
A Demi-Cannon	6.	11	14 367	5.8	4.031	1577	528
A whole Cannon.	7.	12	21.333	6 7	3 709	2422	322
A Cannon Royal.	8.	12.	27.864	7 5	3 298	3382	202

In the preceding Table are ſet down the Names, Diameters of Bores, and Lengths of the Chaſes, of ſeveral Pieces of our *Engliſh* Ordnance, with their requiſites of Powder and Ball, greateſt Randoms, and comparative Forces and Times. Its Uſe is thus: The firſt Column next the Left-hand gives the Name of each Piece, the ſecond Column gives the Diameter of their Bores in Inches and decimal Parts of an Inch, the third ſhews the Length of their Chaſes in Feet and decimal Parts of a Foot, the fourth the Requiſite of Powder to each Piece in Pounds and decimal Parts of a Pound, the fifth has the Diameter of each Ball or Bullet in

Inches and Tenths, ſuppoſing four Pounds to be the Requiſite of the Saker; the Sixth contains their greateſt * Randoms in Miles and decimal Parts of a Mile, ſuppoſing the greateſt Random of the Saker to be 5.654 Miles, as found by Experiment; the ſeventh contains their comparative Forces one to another, when taken in like Places; in the eighth is the comparative Times of the Ranges of their Shot on equal Elevations, that is thus: Suppoſe a Falconet and Demi-Culverin be elevated to the ſame Degree, then the Force of the Falconet to that of the Demi-Culverin, is as 61 to 733, and their Times of Continuance in the Air, is as 14898 to 1379.

To know the different Fortifications of a Piece of Ordnance.

In fortifying any Piece of Ordnance, there are three Degrees obſerved, *viz. Baſtard*, *Legitimate*, and *Double Fortified.*

Baſtard are ſuch as are the leaſt fortified of all.

Legitimate are ſuch as are ordinarily fortified, that is, more than the Baſtard.

Double Fortified Pieces are ſuch as are fortified above either of the former, and are termed extraordinary.

The Fortification of any Piece of Ordnance, is accounted by the Proportion of the Thickneſs of the Metal at the Touch-hole, Trunnions and the Muzzel, compared to the Diameter of the Bore.

The Baſtard Cannon have $\frac{12}{16}$ at their Touch-hole, $\frac{9}{10}$ at their Trunnions, and $\frac{5}{6}$ at their Muzzel of the Diameter of the Bore, in Thickneſs of Metal.

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* *Random ſignifies the Angle of Elevation, and Range the Diſtance the Shot is flung.*

Legitimate Pieces, or ordinary fortified Cannons, have $\frac{7}{8}$ at the Touch-hole, $\frac{5}{8}$ at the Trunnions, and $\frac{3}{8}$ at the Muzzel.

The *double fortified* Cannon have one Diameter of the Bore in Thickneſs of Metal at the Touch-hole, $\frac{11}{16}$ at the Trunnions, and $\frac{7}{16}$ at their Muzzel. Now all double fortified Culverins, *&c.* are 1 $\frac{1}{8}$ at the Touch-hole, $\frac{15}{16}$ at the Trunnions, and $\frac{9}{16}$ at the Muzzel; and the ordinary fortified Culverins are fortified every Way as double fortified Cannons, and leſſened Culverins as ordinary Cannons, in all reſpects.

To know how much Powder is fit for Proof, and for Service for any Piece of Ordnance.

For *Cannons* take $\frac{4}{5}$ of the Weight of their Iron Bullet, of good Corn Powder for Proof, and for Service $\frac{1}{2}$ the Weight of the Iron Bullet is ſufficient, eſpecially for Iron Ordnance, which will not endure ſo much Powder as Braſs ones will receive for $\frac{1}{4}$ in Weight; for Culverins allow the whole Weight of the Shot for Proof, and $\frac{2}{3}$ for Service. For Sakers and Falcons take $\frac{4}{5}$ of the Weight of the Shot; and for leſſer Pieces, the whole Weight may be uſed in Service, until they grow hot; but then there muſt be ſome Abatement made at Diſcretion, and take $\frac{1}{11}$ of the Weight of their Bullets for Proof.

To know what Bullet is fit to be uſed in any Piece of Ordnance.

The Bullet muſt be ſomewhat leſs than the Bore of the Gun, that ſo it may have Vent in the Diſcharge, ſome Authors affirm $\frac{1}{4}$ of an Inch leſs than the Bore will ſerve all Ordnance; but this Vent is too much for a *Falconet*, &c. and too little for a Cannon, therefore they are not to be approved; the beſt is Mr *Phillips* his Proportion, which is to divide the Bore of the Gun into twenty equal Parts, and let the Diameter be $\frac{19}{20}$ thereof, according to which Proportion the preceding Table is calculated.

By knowing the Proportion of Metals one to another, and by knowing the Weight of any Ball, to know what any other ſhall weigh.

The common Proportions for Metals are theſe:

Lead is to Iron, as 2 to 3
Lead is to Braſs, as 24 to 19
Lead is to Stone, as 4 to 1
Iron is to Lead, as 3 to 2
Iron is to Braſs, as 16 to 18
Iron is to Stone, as 3 to 8

The more exact Proportion betwixt Metals are thus known; admit a Cube or Ball of Gold weigh 100lb. a Cube of any of thoſe Metals enſuing of the ſame Bigneſs will bear ſuch Proportion to the ſaid Cube of Gold, as the following Table expreſſes.

	lb.	*pts.*		*lb.*	*pts*
Gold	100.	00	Iron	42.	1
Quickſilver	71.	43	Tin	38.	9
Lead	60.	53	Stone	15.	8
Silver	54.	39	Water	05.	6
Braſs	47.	47			

By the help of this Table, having the Weight of a Ball of any Metal, with its Diameter propoſed, it is eaſy to find the Weight of any other Ball, either of the ſame or different Metal, whoſe Diameter is given, and *Contra*.

In order to this, we ſhall take Dr *Wybard*'s Opinion in his *Tactometria*, that a Bullet of caſt Iron, whoſe Diameter is four Inches, weighs nine lb. *Averdupoize* Weight. This being granted, ſuppoſe the Diameter of an Iron Ball be ſix Inches, what muſt it weigh?

For determining this Queſtion, and others of the like Nature, this is the Rule: As the Cube of the firſt Diameter to the Cube of the ſecond, ſo is the Weight of the firſt to the Weight of the ſecond.

Now the Cube of 4 is 64, and the Cube of 6 is 216, therefore I ſay,

As 64 to 216, ſo is 9 to 30 $\frac{24}{64}$, or 30 lb. 6 oz.

If the Weight of a Braſs Bullet had been required whoſe Diameter is ſix Inches, firſt calculate its Weight as if it were Iron, and then by the preceding Table ſay, as 42 lb. 10 oz. to 47 lb. 37 pts. ſo is 30 lb. 6 oz. to 34 lb. 2 oz. near, which is the true Weight of it, were the Ball Braſs, and had ſix Inches Diameter.

How to tertiate, quadrate, and diſpart, a Piece of Ordnance.

Firſt, To *tertiate* a Piece, is to find whether it hath its due Thickneſs at the Trunnions, Touch-hole and Neck, if the Trunnions and the Neck are in their due Order, and the Chaſe ſtreight.

Secondly, To *quadrate* a Piece mounted, is to ſee whether it be directly placed, and equally poized in the Carriage, which is known by finding in the Convex Superficies of the Baſe and Muzzel Ring, the Point which is perpendicular over the Soul of the Piece, which may be found by the Gunner's Inſtrument, called a Level, an Inſtrument whoſe uſe is ſo vulgarly known that it needeth not my Explanation.

Thirdly, To *diſpart* a Piece, is to fix or elevate on the Convex Point of the Muzzel Ring, a Mark as far diſtant from the Cylinder, or Soul of the Piece, as is the Point of the Baſe Ring to the End, that the viſual Ray, which paſſeth by theſe Marks, may be parallel to the Chaſe, Soul, or Cylinder of the Piece; now the *Diſpart*, i. e. the Difference of the Semi-Diameters of the Corniſhes may be taken by a Pair of Calliper Compaſſes; which found, place on the Top of the Corniſh Ring, near the Muzzel, over the Middle of the inferior Cylinder.

Some general Rules to be obſerved in Shooting in long Guns and Mortars.

Firſt, That a Shot at right Angles ſtrikes more violent and furiouſly than at oblique Angles, therefore Gunners uſe, when they are to batter down a Tower, Wall, or Earth-work, to ſhoot point blank at the Object, *Tire* by *Tire*, by diſcharging all the Pieces in Battery againſt the ſelf-ſame Object in the ſame Inſtant; holding it for a Maxim, That ten Cannons diſcharged together do far more Execution than diſcharged one after another; now at oblique Angles, they ſhoot either Croſs-ways or by rebounding.

Secondly, That the ſpeedieſt Way to make a Breach in the Wall, *&c.* is by ſhooting at the Object from two Batteries, which ruins far more ſpeedily than by ſtriking the Object with one Battery at right Angles, although that one Battery hath as many Cannon as the other two hath.

Thirdly, That if you were to batter a Flank, covered with an Orillon (which becauſe you cannot poſſibly batter it right forward) you muſt therefore of neceſſity batter it obliquely, by Way of rebounding, thus: Chooſe a fit Place in the Courtain to be your Object, on which you may play with your Battery obliquely, ſo that by a Rebound the Shot may leap into the Flanks; holding it for a Maxim, in this Operation. That the Angles of Incidence and Reflection are equal.

Fourthly, In Mortars, before you make a Shot at any Place, you find the Diſtance thereof from your Mortar.

Fifthly, That the Bombs or other Bodies that are to be ſhot, be of equal Weight; otherwiſe the Shots will vary.

Sixthly, That the Carriage in Breadth be always on a Level, and without any Deſcent, that ſo it may not leap in diſcharging.

Seventhly, That the Powder with which the Mortar is loaded, be always of the ſame Force and Weight.

Eighthly, That the Charge of the Mortar, as well in Powder as in Wadding, be always rammed in with Blows equally heavy, and of equal Number.

Ninthly, That the Wads be always either of Wood or Tompions, or elſe of Okam, for the ſtrongeſt drives it fartheſt.

Tenthly, That the Fuſes be newly made, in thoſe Days that they are to be uſed, and that they be made of a Compoſition proportionable to the Range that the Shoot ſhall make in the Air, ſo that the Bomb may break in the very Moment of its Fall, which Compoſition muſt be ſuch, that though it fall in the Water, yet not to extinguiſh, but the Bomb there to break. Now before we proceed any farther, I think it neceſſary, to ſhew how to compoſe your Ingredients for your Fuſe.

To make Fuſes for Bombs, &c.

The Compoſition for Bombs muſt be of a ſlow Motion, that ſo Time enough may be given to throw either Bombs, Granadoes, Fire-balls, Thundering-Barrels, *&c.* They are compounded of theſe Ingredients thus: Take a Pound of Gunpowder, $\frac{4}{16}$ of Sulphur, $\frac{4}{16}$ of Salt-Petre, well beaten, dry, and ſifted ſeparately, then mix it, and make up your Fuſe thereof; or take Powder of Benjamin, and Small-Coals, all well beaten, and mixed together with ſome Oil of Peter, and ſo fill your Fuſe therewith.

* * *

Of Shooting in general.

AS to the *ſeveral Shootings* in *Artillery*, Authors have differed much in their Opinions; but now they all unanimouſly agree, That a Ball being ſhot forth deſcribes in the Air a *Parabolick* Line, as has been proved by *Gallilæus*, *Torricellius*, and of late by the ingenious Capt. *Halley*, in a Diſcourſe of Gravity, publiſhed in *Philoſ. Tranſac. Numb.* 179. In which Diſcourſe he mathematically demonſtrates that the Motion of all Projects is in the *Curve* of *Parabola*. From the Properties of which *Curve*, theſe uſeful Things in Gunnery have been deduced.

Firſt, That the Length of the horizontal Ranges are one to another, *as the Sines of the double Angles of Elevation.*

Secondly, That the *Altitudes* of Shots are one to another, *as the verſed Sines of the double Angles of Elevation.*

Thirdly, The Times of Continuance of a Shot in the Air, at different Elevations, are one to another, *as the Sines of the Angles of Elevation.*

From theſe three Propoſitions all that is neceſſary, in the Practice of Gunnery, may be known.

As *Firſt*, Suppoſe I make a Shot upon a given Elevation, and then meaſure the Length of the Range Shot; you may from that Diſtance by the preceding Propoſition tell the Length of the Ranges Shot, upon any other Elevation, uſing the ſame *Force* or *Charge* of Powder.

For Example: Suppoſe a Shot with a Mortar be made upon fifteen Degrees Elevation, and meaſuring the Range find it 300 Yards, it is required to know the utmoſt Range, or how far it will ſhoot at forty-five Degrees.

Say,

As Sine 30 Degrees	9.	698978
To Sine 90 Degrees	10.	000000
So is 300 Yards	12.	477121
To 600 Yards	2.	778151

So that the greateſt horizontal Range (of a Mortar that throws a Bomb upon fifteen Degrees Elevation 300 Yards) is 600 Yards.

After the ſame Manner are the Range upon all Elevations found. As ſuppoſe you would find the horizontal Range upon thirty-five Degrees Elevation.

Say,

As Sine 30	9.	698970
To Sine 70	9.	973986
So is 300 Yards	2.	477121
	12.	451107
To 565 Yards	2.	752137

Again, Suppoſe I had a Mind to find what Elevation of my Piece is requiſite to hit a Mark at 400 Yards Diſtance from me.

Say,

As 300 Yards	2. 477121
To Sine 30 Degrees	9. 698970
So is 400 Yards	2. 602060
	12. 301030
To Sine 41, 48	9. 823909

The half of which is 20, 54, the ∠ of Elevation for the Piece to throw a Bomb 400 Yards.

And thus, this one Property is ſufficient without a Table of Ranges, the Table of Ranges being made by this Proportion.

And here note, That you may work theſe Proportions by the Lines of *artificial Numbers* and *Sines*, which are put upon the common *Gunters Scales.*

From this Propoſition it follows, that the greateſt horizontal Range of any Project is at forty-five Degrees, and that the horizontal Ranges above and below forty-five Degrees are equal.

Secondly, The *Altitudes* of Shots are one to another as the verſed Sines of the double Angles of Elevation.

And here note, That the greateſt Height that a Ball will aſcend to when ſhot perpendicular upright, is ½ the greateſt Range; and therefore knowing the greateſt Range of your Piece by the firſt Propoſition, which ſuppoſing 600 Yards, and you would know how high the Ball would fly when the Piece is ſet to forty Degrees of Elevation.

Say,

As the verſed Sine of 180 (*viz.* twice the *Rad.*) is to the verſed Sine of eighty (*viz.* twice forty Degrees) ſo is ½ the greateſt Range to the Altitud required.

So that multiplying the verſed Sine of eight Degrees, which is 8263, by 300 Yards, half th greateſt Range, and dividing the Product by 2000 the verſed Sine of 180, the Quot. is near 124 Yards, the perpendicular Height.

See the following Operation.

8263
300

2(0000)247|8900|124 *propè.*

And on the contrary, if the greateſt horizonta Range was given, and the perpendicular Heigh of any Shot known, then to find the Angle o Elevation.

Say,

As 300 Yards half the greateſt horizontal Range to the verſed Sine of 180 Degrees, *viz.* 20000, ſ is the given Perpendicular Height of a Shot, ſuppoſe 124 Yards to 8263, near the verſed Sine o eighty Degrees, half of which is forty Degrees, th Angle the Piece muſt be ſet to.

Thirdly, The *Times* of the Continuance of a Sho in the Air at different Elevation, are one to anothe as the Sines of the Angles of Elevation.

Now ſuppoſe I had made a Shot upon forty-five Degrees of Elevation, and by a Watch which hath a Hand to ſhew Seconds, I find that the Shot continues in the Air twelve Seconds, it is required to know how long it will continue in the Air when ſhot at ſeventy-five Degrees of Elevation.

Say,	
As the Sine of 45 Degrees	9. 849485
Is to 12 Seconds	1. 079181
So is the Sine of 75 Degrees	9. 984944
	11. 064125
To 16 Seconds	1. 214640

By this Rule *Fuſes* are adjuſted, as to their Time of Burning, that they might break juſt at their fall.

Again, if at fifty-four Degrees of Elevation a Shot continues in the Air fourteen Seconds, how many Degrees was the Piece elevated to, when the Shot continued ſixteen Seconds in the Air?

I might have proceeded further, in ſhewing how from ſeveral Data's to find the *Requiſite* of *Powder*, Length of the *Chaſe*, *Diameter* of the Ball, *&c.* But theſe not being ſo abſolutely neceſſary (eſpecially to be acquired after this Manner) I have omitted them; and ſhall conclude this Tract with a very uſeful and eaſy Table, by which may be found the horizontal Random of any Shot from ſome given Elevation, as alſo the Elevation being given, to throw a Shot to any Place at demand. And that without the Help of the *Logarithmetical* Tables.

A TABLE

A TABLE of the horizontal Diſtances of Projections.

Deg. *Elev*	0	6	12	18	24	30	*Mi.*
0	0	7	14	21	28	35	89
1	70	77	84	91	98	105	88
2	140	146	153	160	167	174	87
3	209	216	223	230	237	244	86
4	278	285	292	299	306	313	85
5	347	354	361	368	375	382	84
6	416	423	429	436	443	450	83
7	484	491	497	504	511	518	82
8	551	558	565	571	578	585	81
9	618	625	631	638	645	651	80
10	684	691	697	704	710	717	79
11	749	756	762	769	775	781	78
12	813	820	826	833	839	845	77
13	877	883	889	896	902	908	76
14	939	945	951	957	964	970	75
15	1000	1006	1012	1018	1024	1030	74
16	1060	1066	1072	1078	1083	1089	73
17	1118	1124	1130	1136	1141	1147	72
18	1170	1181	1187	1192	1198	1284	71
19	1231	1237	1242	1248	1253	1259	70
Mi.	60	54	48	42	36	30	*Deg.* *Ele.*

The Table continued.

Deg. *Elev.*	0	6	12	18	24	30	*Mi.*
20	1286	1291	1296	1302	1307	1312	69
21	1338	1343	1349	1354	1359	1364	68
22	1389	1394	1399	1404	1409	1414	67
23	1439	1444	1448	1453	1458	1463	66
24	1486	1491	1496	1500	1505	1509	65
25	1532	1537	1541	1545	1550	1554	64
26	1576	1580	1585	1589	1593	1597	63
27	1618	1622	1626	1630	1634	1638	62
28	1658	1662	1666	1670	1674	1677	61
29	1696	1700	1703	1707	1711	1714	60
30	1732	1736	1739	1742	1746	1749	59
31	1766	1769	1772	1776	1779	1782	58
32	1798	1801	1804	1807	1810	1831	57
33	1827	1830	1833	1836	1838	1841	56
34	1854	1857	1860	1862	1865	1867	55
35	1879	1882	1884	1886	1889	1891	54
36	1902	1904	1906	1908	1911	1913	53
37	1923	1924	1926	1928	1930	1932	52
38	1941	1942	1944	1946	1947	1949	51
39	1956	1958	1959	1961	1962	1963	50
40	1970	1971	1972	1973	1974	1975	49
41	1981	1981	1982	1983	1984	1985	48
42	1989	1990	1990	1991	1992	1992	47
43	1995	1996	1996	1996	1997	1997	46
44	1999	1999	1999	1999	2000	2000	45
Mi.	60	54	48	42	36	30	*Deg.* *Elev.*

The Table continued.

Deg. *Elev.*	36	42	48	54	60	*Min.*
0	42	49	56	63	70	89
1	112	119	126	133	140	88
2	181	188	195	202	209	87
3	251	258	265	271	278	86
4	320	327	334	340	347	85
5	388	395	402	409	416	84
6	457	463	470	477	484	83
7	524	531	538	545	551	82
8	591	598	605	611	618	81
9	658	664	671	677	684	80
10	723	730	736	743	749	79
11	788	794	801	807	813	78
12	852	858	864	870	877	77
13	914	920	927	933	939	76
14	976	982	988	994	1000	75
15	1036	1042	1048	1054	1060	74
16	1095	1101	1107	1113	1118	73
17	1153	1159	1164	1170	1176	72
18	1209	1215	1220	1226	1231	71
19	1264	1269	1275	1280	1286	70
20	1317	1323	1328	1333	1338	69
21	1369	1374	1379	1384	1389	68
22	1419	1424	1429	1434	1439	67
23	1467	1472	1477	1482	1486	66
24	1514	1519	1523	1528	1532	65
Mi.	24	18	12	6	0	*Deg.* *Elev.*

The Table continued.

Deg. Elev.	36	42	48	54	60	*Min.*
25	1559	1563	1567	1572	1576	64
26	1601	1606	1610	1614	1618	63
27	1642	1646	1650	1654	1658	62
28	1681	1685	1689	1692	1696	61
29	1718	1721	1725	1729	1732	60
30	1753	1756	1759	1763	1766	59
31	1785	1788	1791	1795	1798	58
32	1816	1818	1821	1824	1827	57
33	1844	1846	1849	1852	1854	56
34	1870	1872	1875	1877	1879	55
35	1893	1896	1898	1900	1902	54
36	1915	1917	1919	1921	1923	53
37	1934	1935	1937	1939	1941	52
38	1950	1952	1953	1955	1956	51
39	1965	1966	1967	1968	1970	50
40	1976	1978	1979	1980	1981	49
41	1986	1987	1988	1988	1989	48
42	1993	1994	1994	1995	1995	47
43	1998	1998	1998	1999	1999	46
44	2000	2000	2000	2000	2000	45
Min.	24	18	12	6	0	*Deg. Elev.*

The Uſe of the preceding Table is thus.

The Left-hand Page is the Degree of Elevation, and the Top are the Minutes to the 10 of a Degree, that is, to 6, 12, and 18.

Suppoſe now a Piece elevated to 13 Degrees 18 Minutes, lays the Ball at 1837 Paces Diſtance, what is his greateſt Random?

Seek in the Table for 13 Degrees, and under 18 Minutes on the Top is 896, the Tabular Diſtance.

Therefore ſay, as 896 to 2000, ſo is 1837 to 4100 Pieces, the greateſt Random of the ſaid Piece.

The ſame would follow, if the Elevation had been 76 Degrees 42 Minutes, that being as much above 45 Degrees, as 13 Degrees 18 Minutes is under, and may eaſily be found by looking on the Right-hand Side in the Bottom of the Table.

Secondly, The greateſt horizontal Projections of a Piece being 41000.4 Paces, how muſt I elevate my Piece to throw a Ball 1737 Paces?

Say, as 41000.4 to 2000, ſo is 1737 to 896 *near*. This Number 896, or neareſt, being found out in the preceding Table, you have in the Left-hand Column 13 Degrees, and in the Head of the Table over the Number you have 18 Minutes, which is the true Elevation of the Chaſe of the Piece to lay a Ball at the afore-mentioned horizontal Diſtance of 1737 Paces; or if you look in the Right-Hand Column, and at the Bottom of the Table, you will find 76 Degrees 42 Minutes, the over Elevation to throw a Piece as aforeſaid.

I might have proceeded farther in giving more Examples, as alſo in relation to the Reſiſtance of the Air (by which all Projects are diverted from deſcribing in the Air a true Parabola) and conſequently that the greateſt Random is not made upon 45 Degrees of Elevation, but at ſome few Minutes under, and ſo will cauſe ſome ſmall Difference in the horizontal Ranges.

But conſidering in ordinary and common Practice, (eſpecially in Service) that with the common Inſtruments we can ſcarce come to the Certainty of a Degree or two, the preceding Table will be near enough, and ſerve very well for ordinary Practice, although the Allowance for the Air's Reſiſtance be not conſidered therein.

FINIS.

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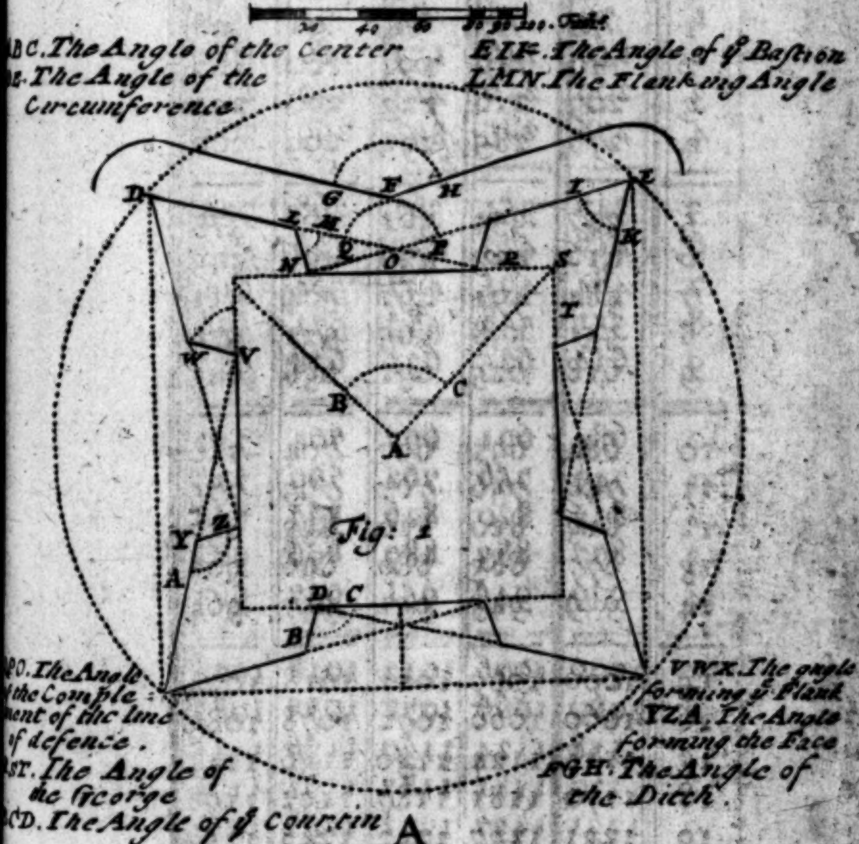
A Figure shewing all the angles in a Square.


20 40 60 80 90 100 . Feet
BC. The Angle of the Center
E. The Angle of the Circumference
EIF. The Angle of ÿ Bastion
LMN. The Flanking Angle
PO. The Angle of the Comple ment of the line of defence.
ST. The Angle of the Gorge
CD. The Angle of ÿ Courtin
VWX. The angle forming ÿ Flank
YZA. The Angle forming the Face
FGH. The Angle of the Ditch.
D G E H I L L M Q O F N R S K T W V B C A Y Z A D C B
Fig: 1

A

12
APR

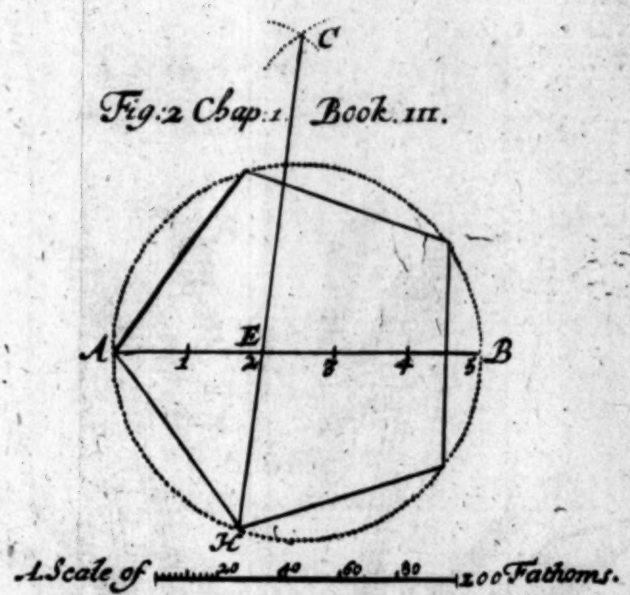


Fig:2 Chap:1 Book.III.

A Draught & Square of Vaubane.

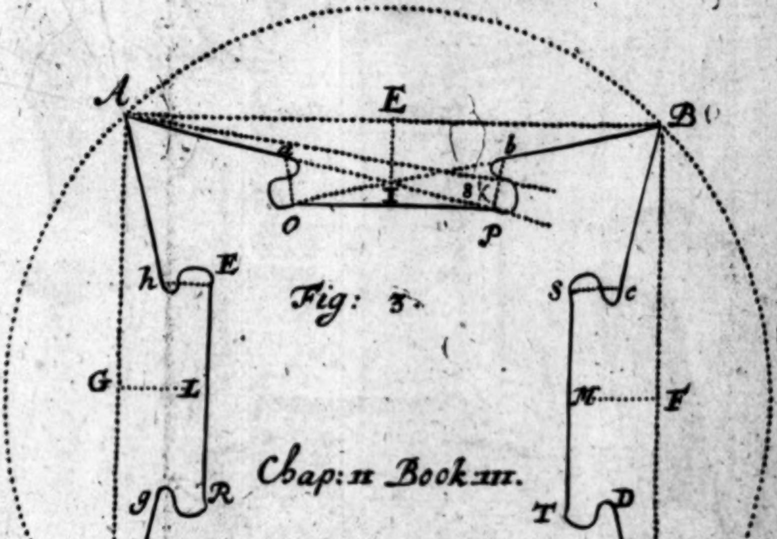
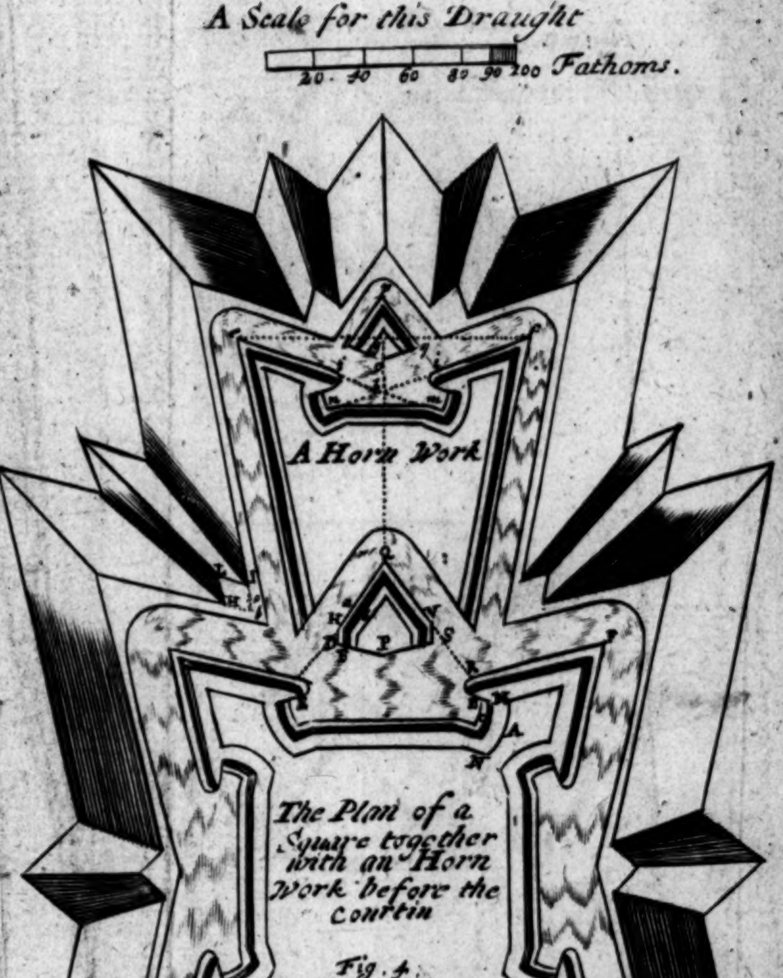


Fig: 3.

Chap:11 Book III.

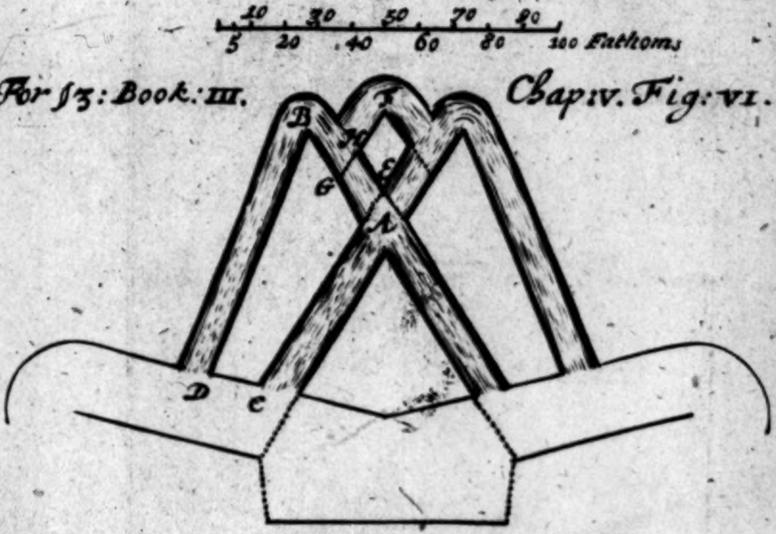


The Plan of a Square together with an Horn Work before the Courtin

Fig. 4.

CHAP III & IV. & VI.
Book III.

For §3: Book: III. Chap: IV. Fig: VI.



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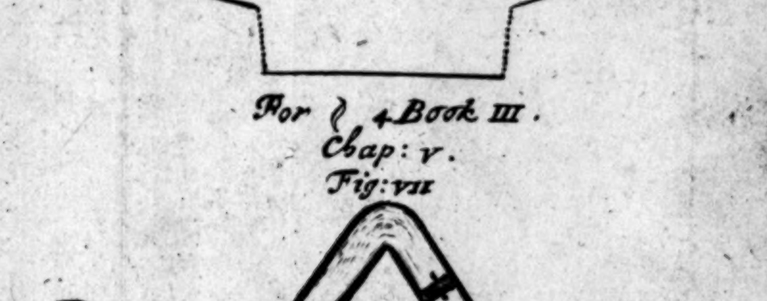

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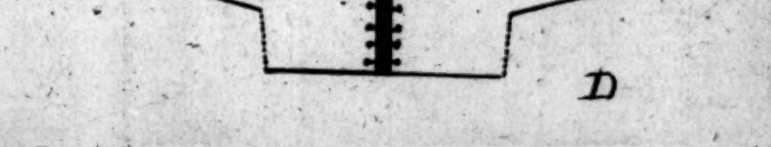
Chap: V.
Fig: VII



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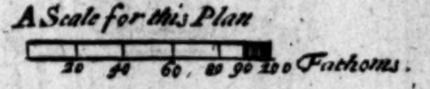


CHAP. VII: Book: III.

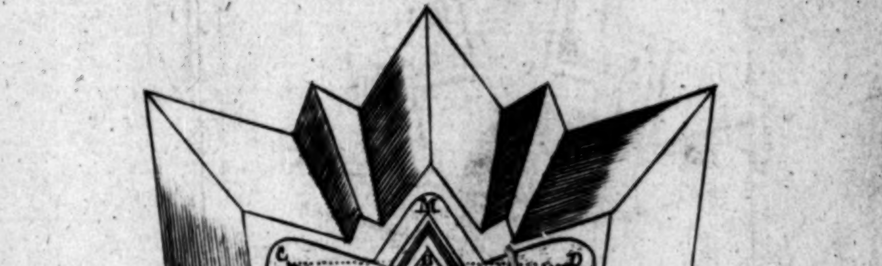
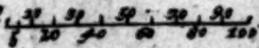


Fig: 8.

The Plan of a Horn Work before the Bastion of a Square.

E

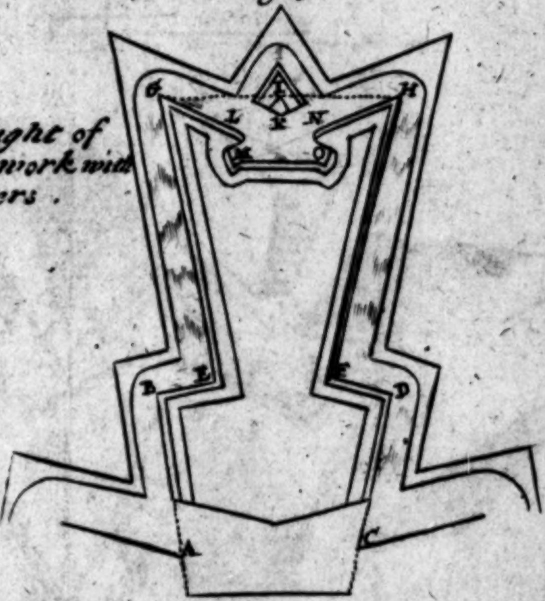
A Scale of 

Fathoms.

CHAP: VIII : Book III.

Fig. 9.

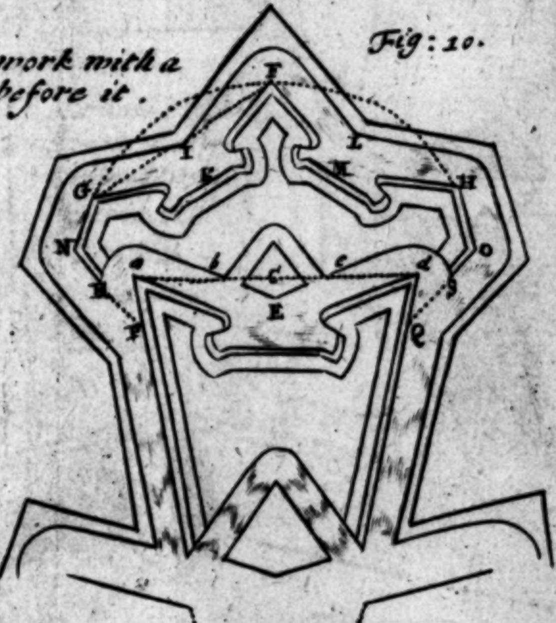
The Draught of a Horn-work with Shoulders.



CHAP: IX. Book. III.

Fig: 10.

a Horn-work with a Crown before it.



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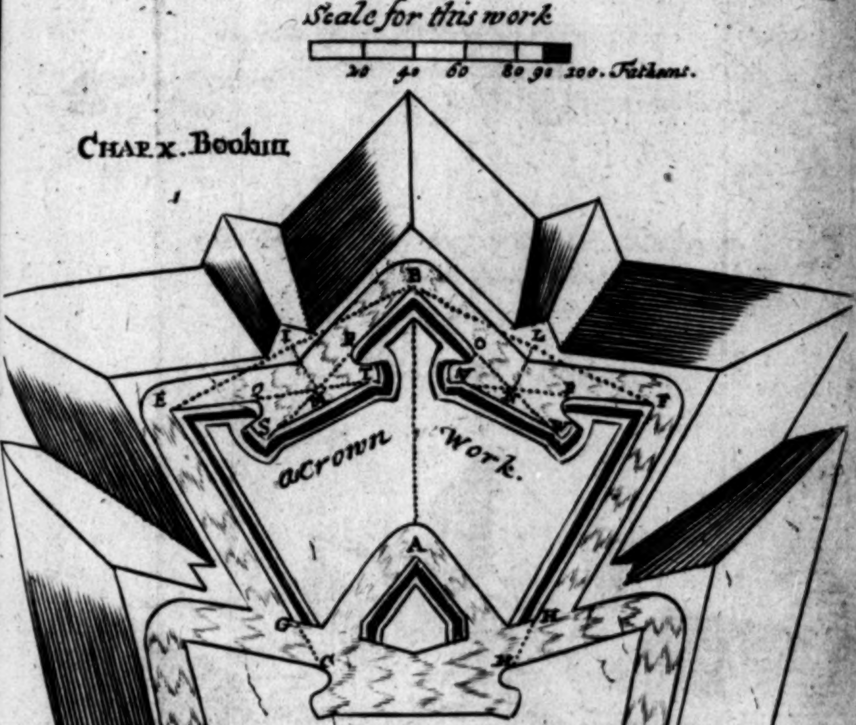


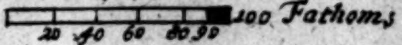
A draught of a Square with a Crown Work before the Courtin

Fig: 11.

A Scale of 100 Fathoms or 600 Foot

The Scale of this Plan

Note a Fathom
is 6 Foot.



a Crown Work before the Baſtion
of a Square Vaubane

CHAP: XI. Book III.

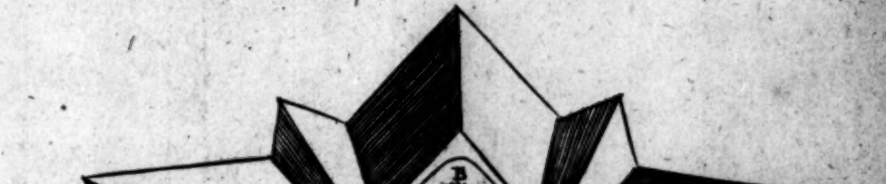
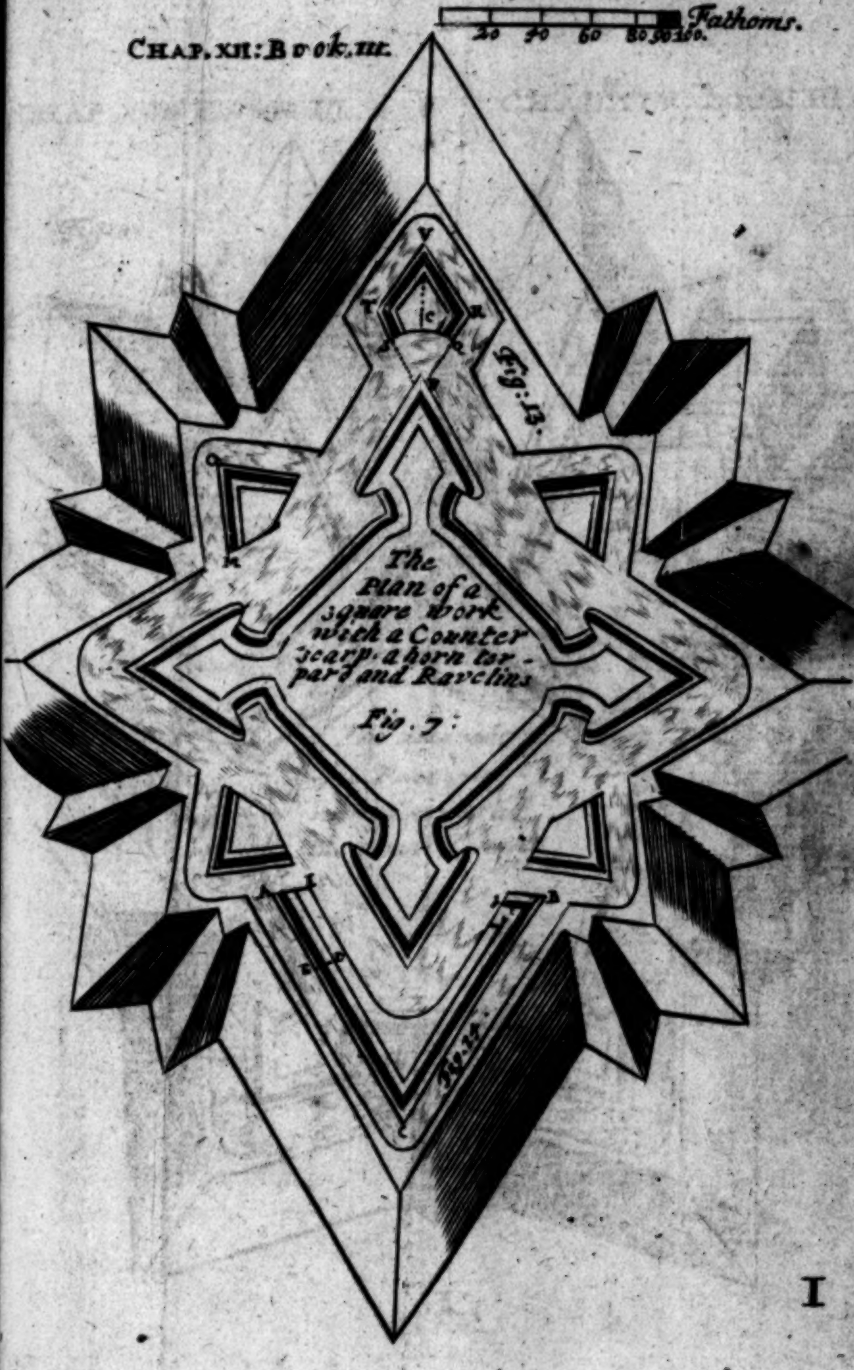


Fig. 12.

CHAP. XII: Book. III.

A Scale for this Plan .



The Plan of a square work with a Counter scarp. a horn torpard and Ravelins

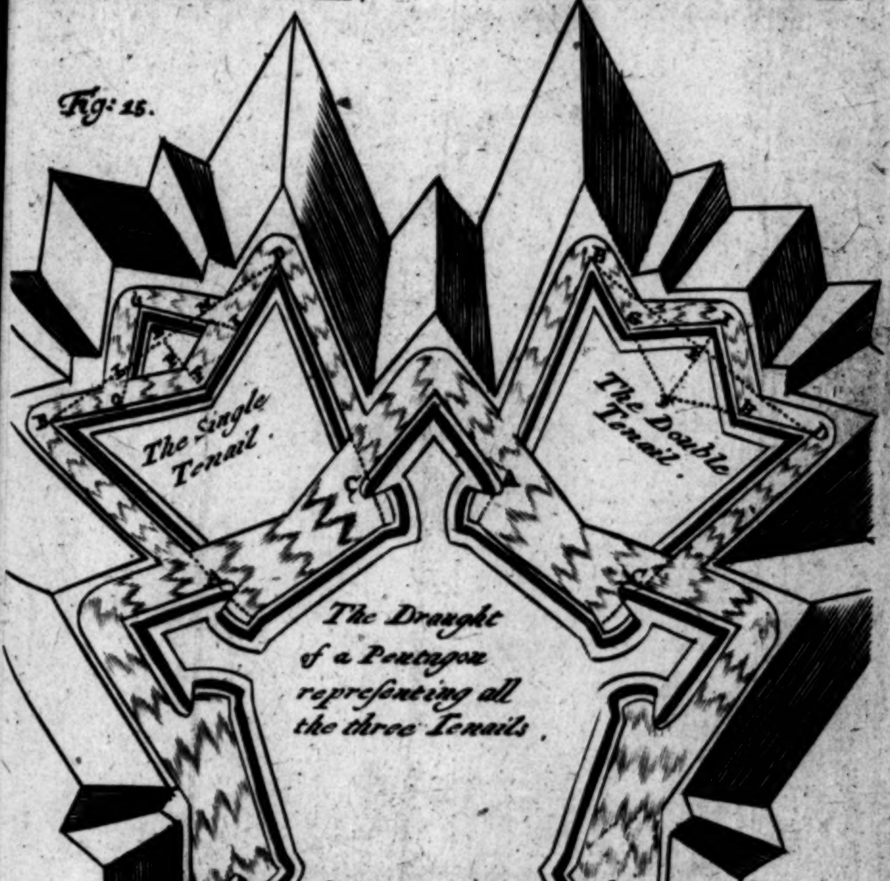
Fig. 7:

I

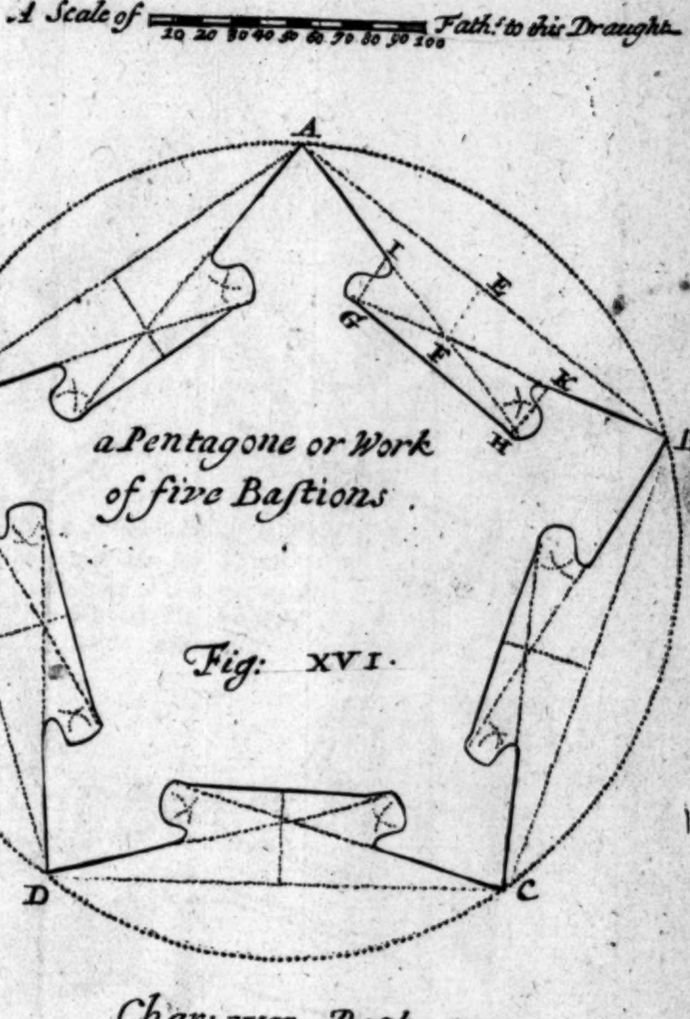
A Scale for this Draught. Fathoms 20 40 60 70 80 90 100

CHAP. XIII. BOOK III. CHAP. XIV. BOOK. III.

Fig: 15.


The Single Tenail.
The Double Tenail.
The Draught of a Pentagon representing all the three Tenails.
B
C
D
B
C
D

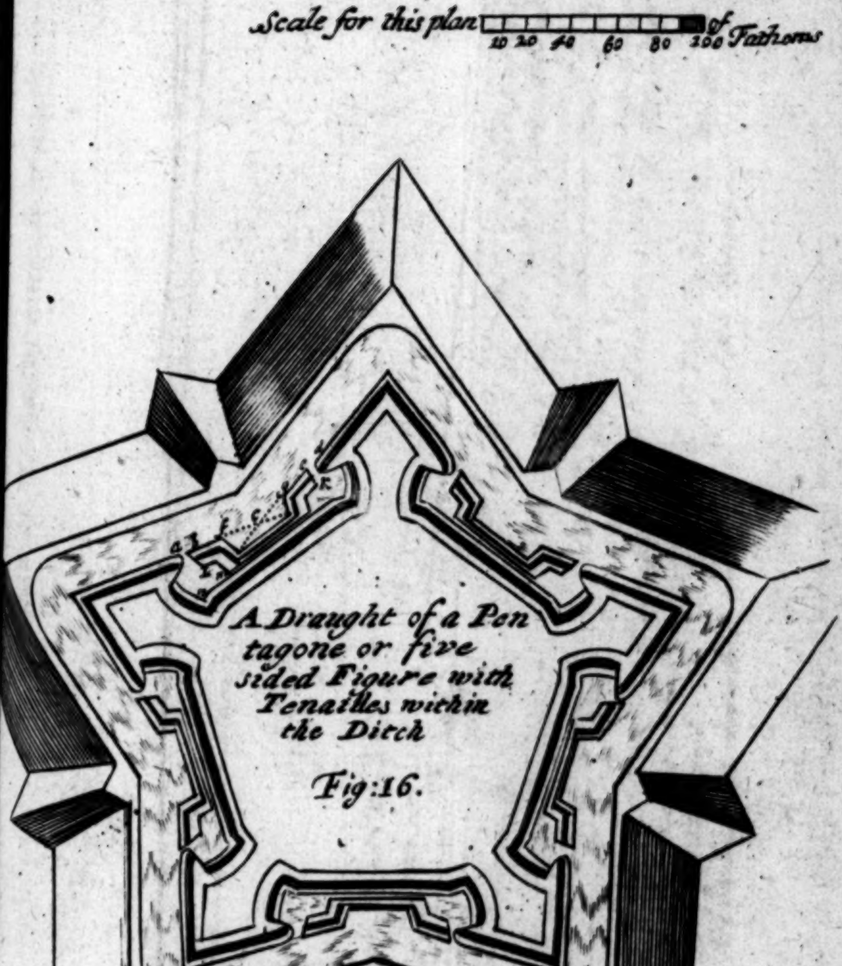
K



a Pentagone or Work of five Baſtions.

Fig: XVI.

Chap: XVI. Book. III.



A Draught of a Pentagone or five sided Figure with Tenailles within the Ditch

Fig:16.

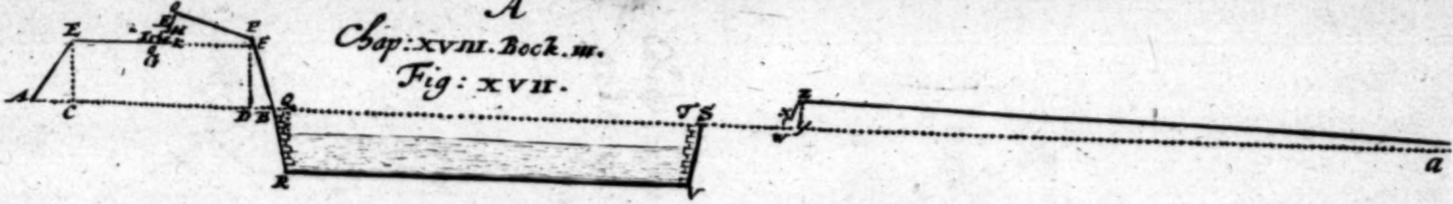
CHAP. VI.

method and of its exteriour Works

method and of its exteriour Works

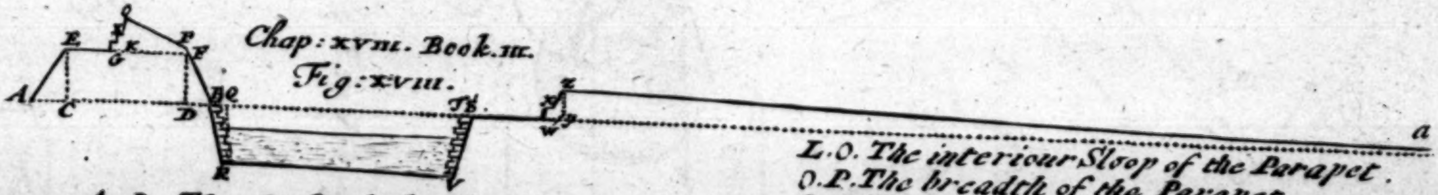
A

Chap: xviii. Book. iii.
Fig: xvii.



B

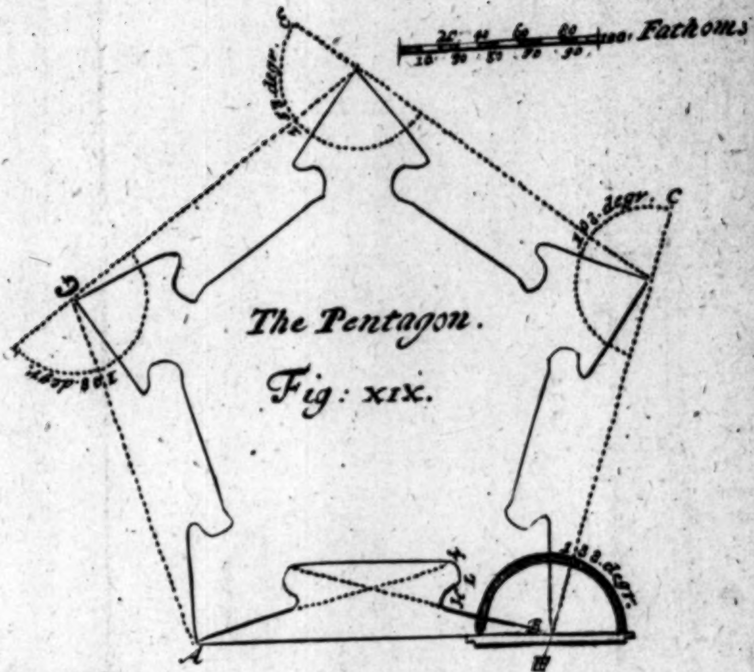
Chap: xviii. Book. iii.
Fig: xviii.



A.B. The Base of the Rampart.
A.C.E. The interiour Sloop of the Rampart.
B.D.F. The exteriour Sloop of the Rampart.
C.E & D.F. The Height of the Rampart.
E.G. The top of the Rampart.
G.I.H. The first foot bank.
H.L.M. The second foot bank.

L.O. The interiour Sloop of the Parapet.
O.P. The breadth of the Parapet.
P.F. The exteriour Sloop of the Parapet.
B.R. The interiour Sloop of the Ditch.
S.V. The exteriour Sloop of the Ditch
B.S. The breadth of the Ditch.

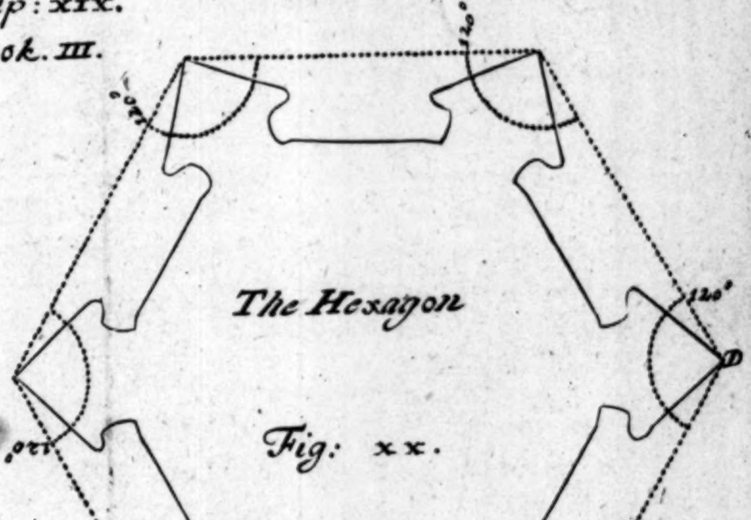
S.W. The cover'd way.
W.a. The Glacis.



The Pentagon.

Fig: XIX.

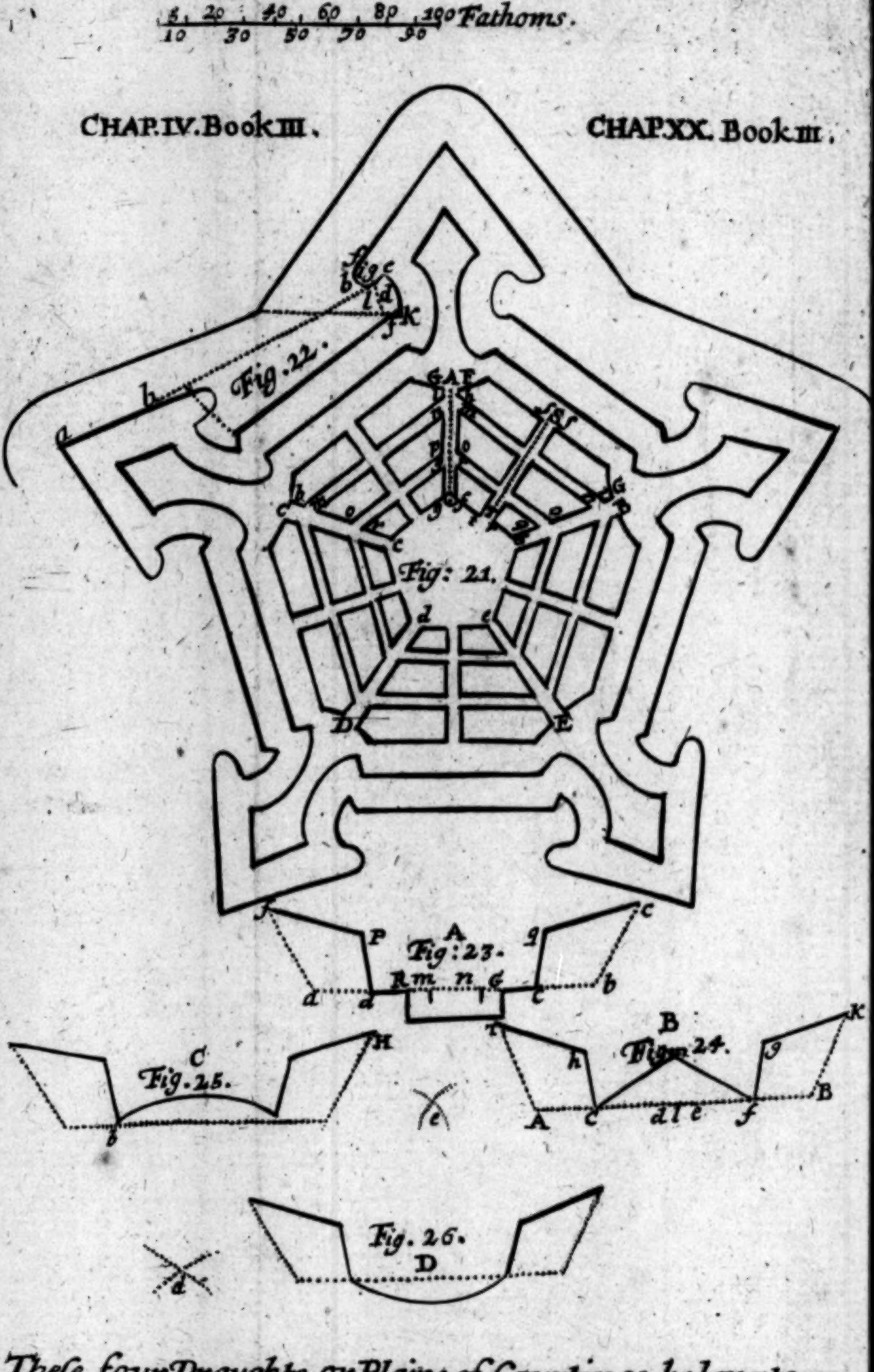
Chap: XIX.
Book. III.



The Hexagon

Fig: XX.

CHAP.IV. Book III. CHAP.XX. Book III.



Theſe four Draughts or Plains of Courtines belong to CHAP.V. Book IV.

P

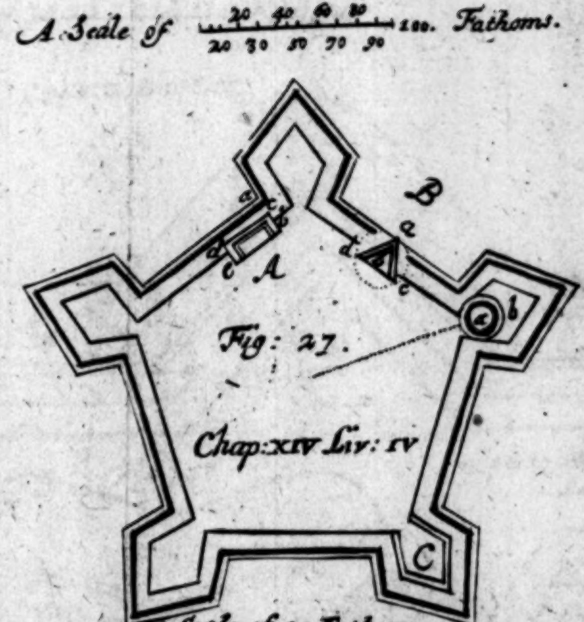


Fig: 27.

Chap: XIV Liv: IV

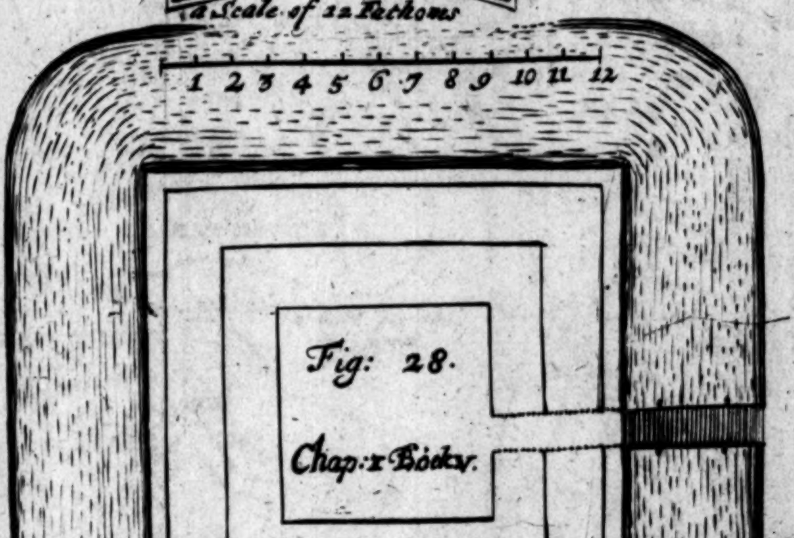


Fig: 28.

Chap: X Book V.

A Scale of 1 2 3 4 5 6 7 8 9 10 Fathoms

CHAP. II Book. V.

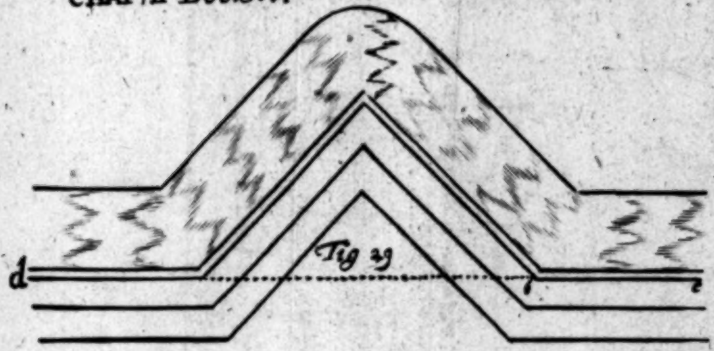
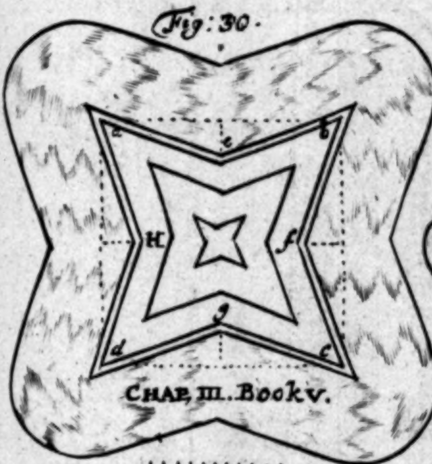


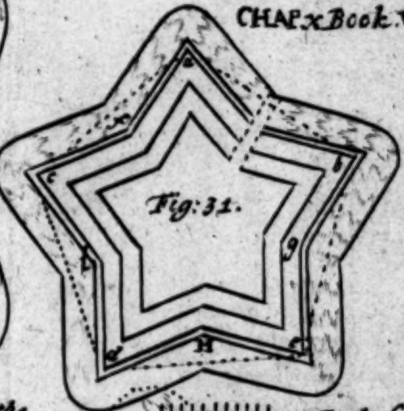
Fig: 30.



CHAP. III. Book V.

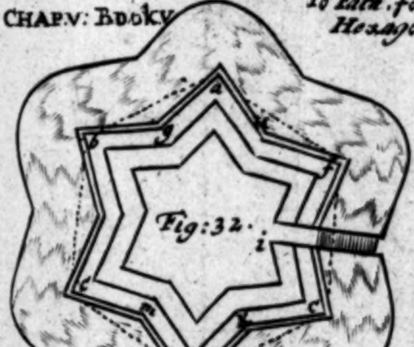
10 Fath. for the Star Pentagon.

CHAP. X Book. V.

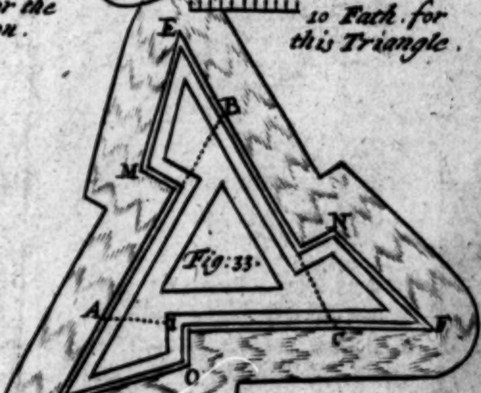


10 Fath. for the Hexagon.

CHAP. V: Book V.



10 Fath. for this Triangle.



CHAP: VI Book. V.

R

A Scale of 10 Fathoms.

A Scale of 10 Fathoms For y^e Square

CHAP. VII. Book III.

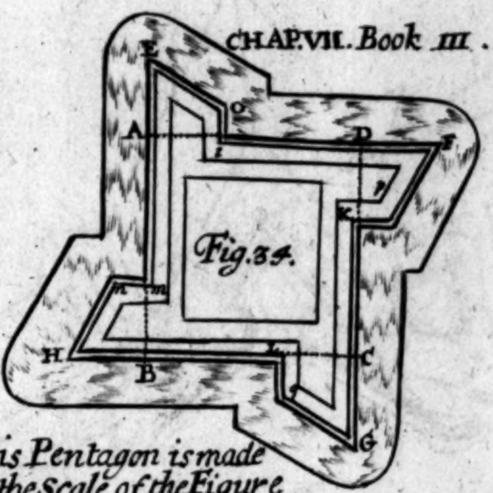
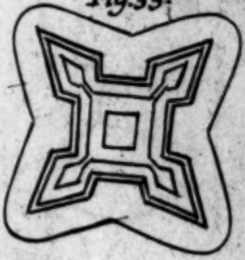


Fig. 34.

This Pentagon is made by the Scale of the Figure above Number 34.

CHAP. VIII. Book IV.

Fig. 35.



CHAP. IX. Book IV.

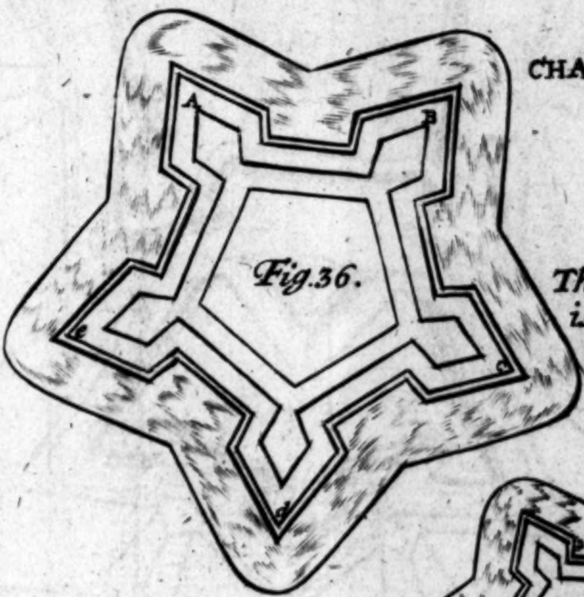


Fig. 36.

This demy-Hexagon is made by the Scale of Fig. 35.

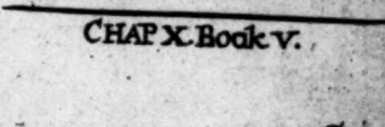
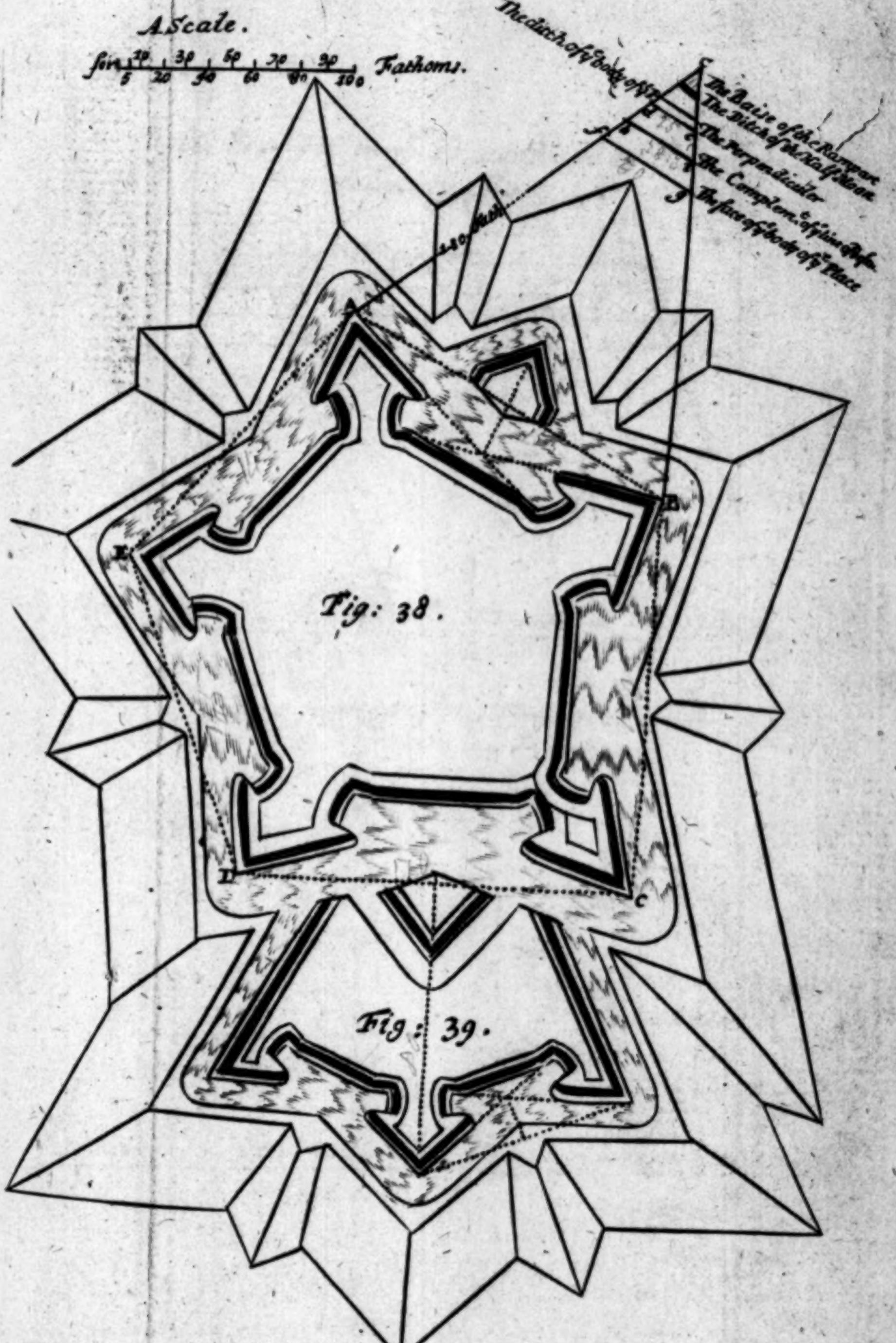


Fig. 37

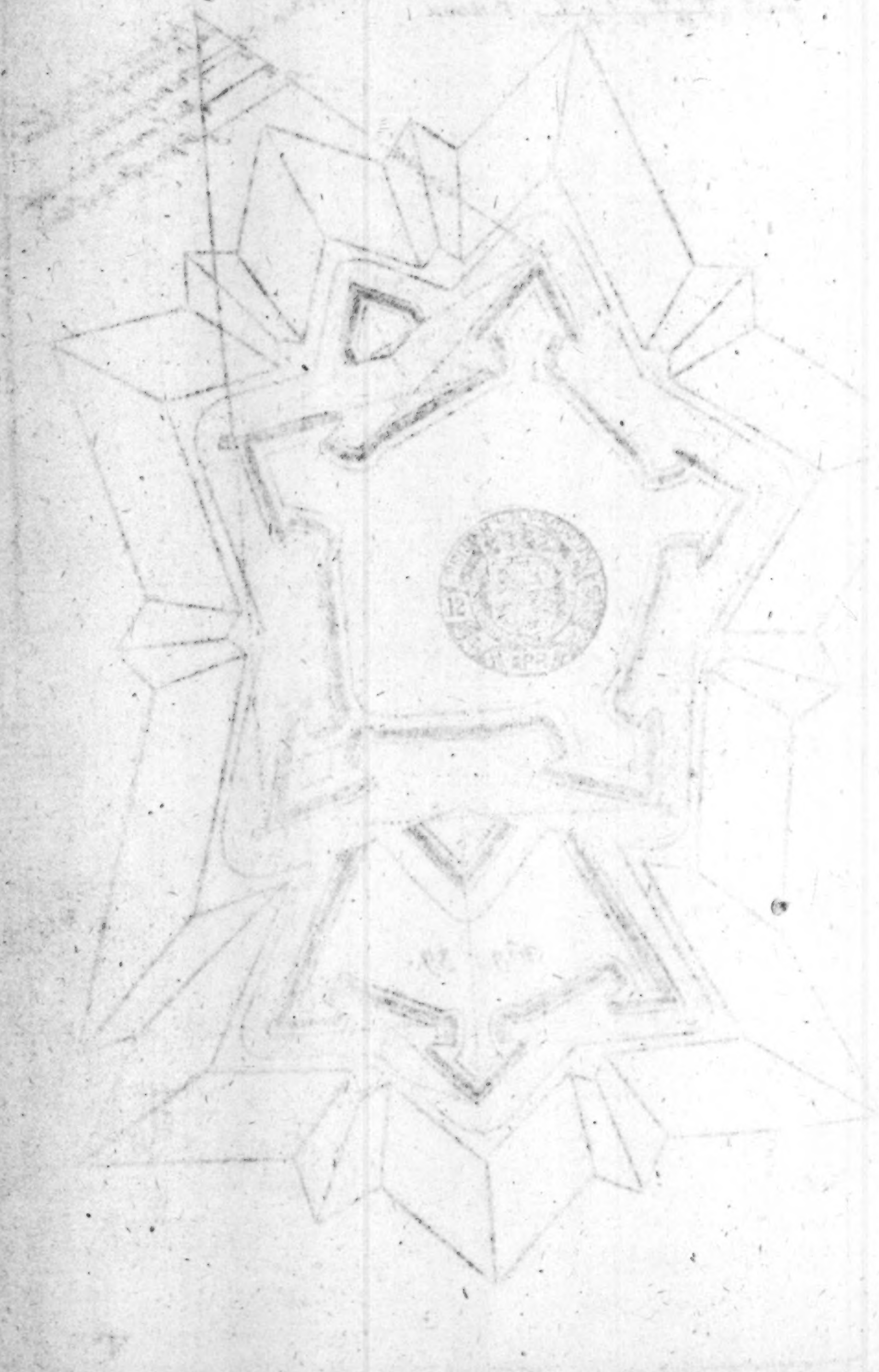
CHAP. X. Book V.


A Scale.
fm 10 30 50 70 90 Fathoms.
5 20 40 60 80 100
The ditch of y^e body of y^e Pl.
The Baise of the Rampart
The Ditch of the Half Moon
The Perpendicular
The Complem.^t of y^e line of Def.
The face of y^e body of y^e Place
C
f
g
180 fath.
A
B
C
D
E
Fig: 38.
Fig: 39.

175
185
160
19
7175

180
5

T



The Scale for these Triangles is in the preceeding page.

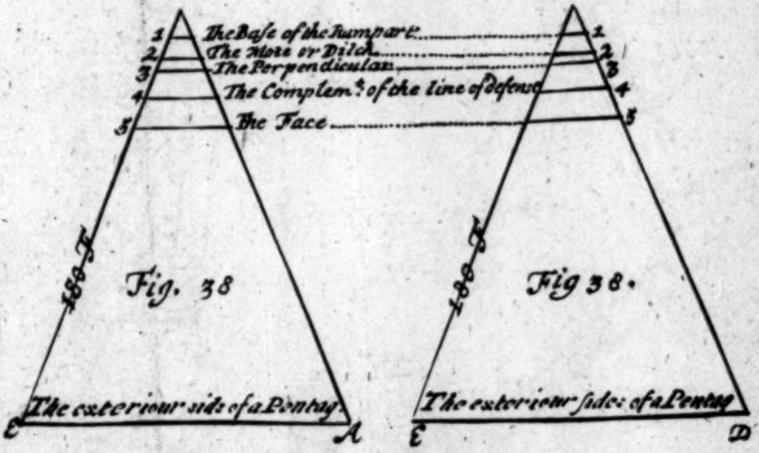

1
2
3
4
5
The Base of the Rumpart
The More or Ditch
The Perpendicular
The Complem.t of the line of defense
The Face
180 F
The exteriour sids of a Pentag
E
A
1
2
3
4
5
180 F
The exteriour sides of a Pentag
E
D

Fig. 38 Fig 38.

The figure of the Triangles of the irregular Pentagon in the preceeding Chap XIII XIV. & XV. Book V.

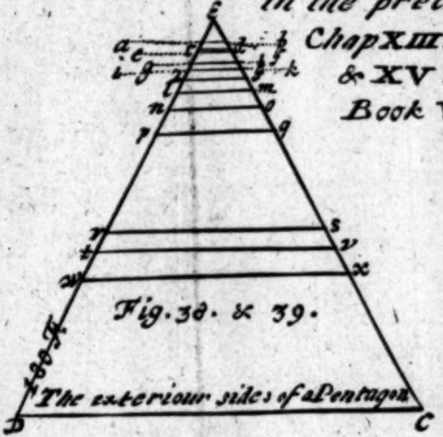


Fig. 38. & 39.

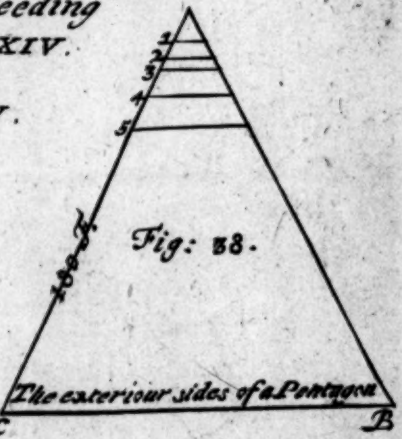


Fig: 38.

V

A Scale for these three Plan's

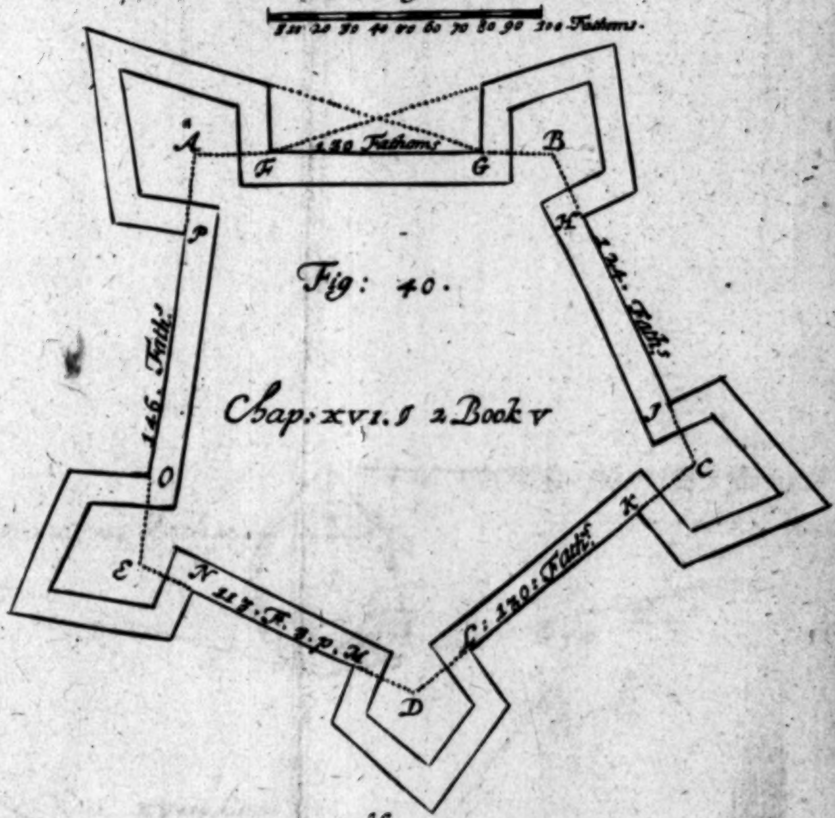


Fig: 40.

Chap: xvi. § 2 Book v

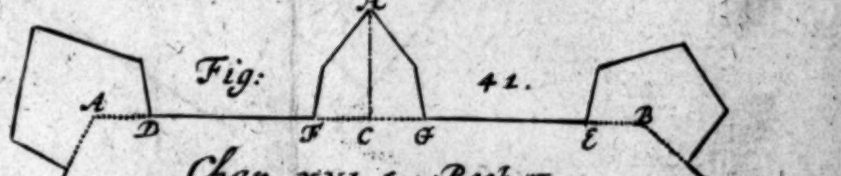
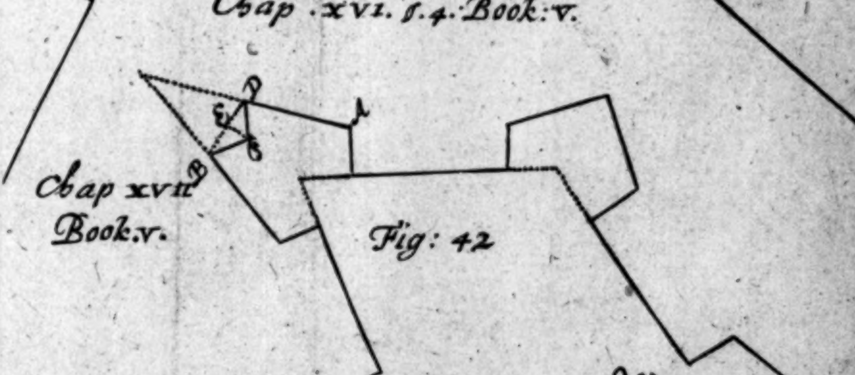


Fig: 41.

Chap. xvi. § 4. Book: v.



Chap xvii Book. v.

Fig: 42

W

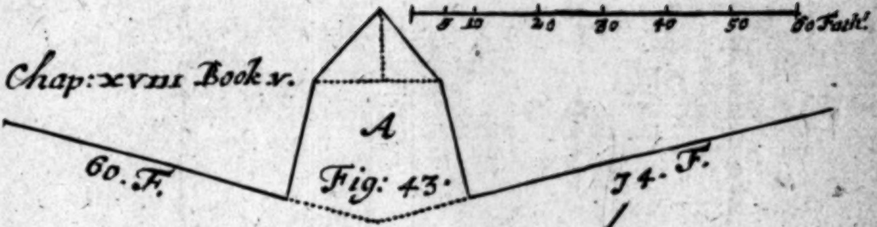


Fig: 43.

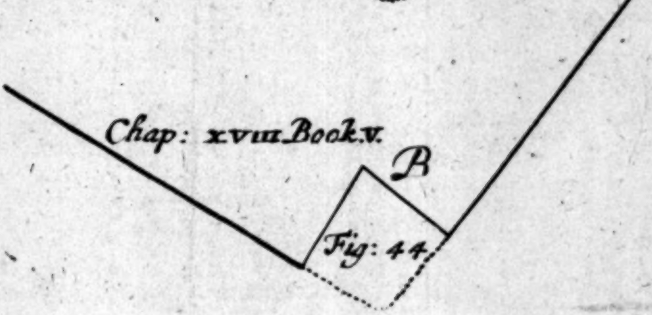


Fig: 44.

X

12 APR

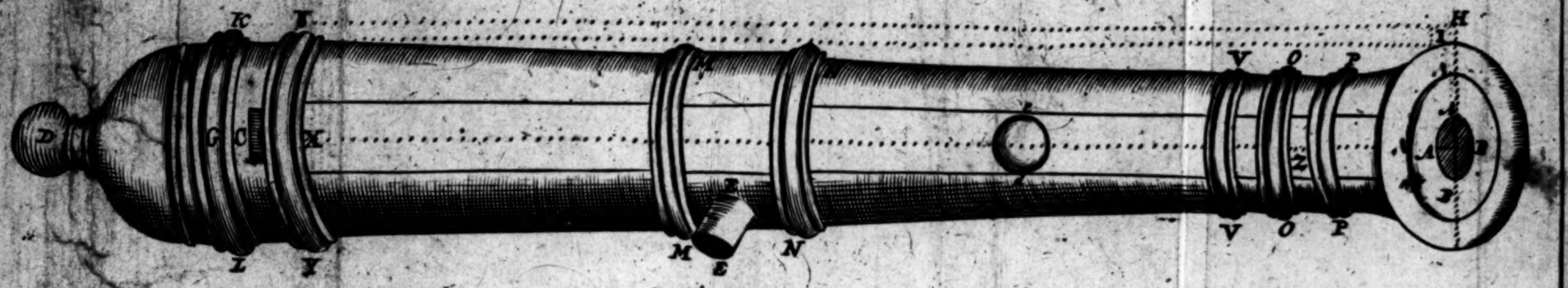


Figure 91

Figure 93.

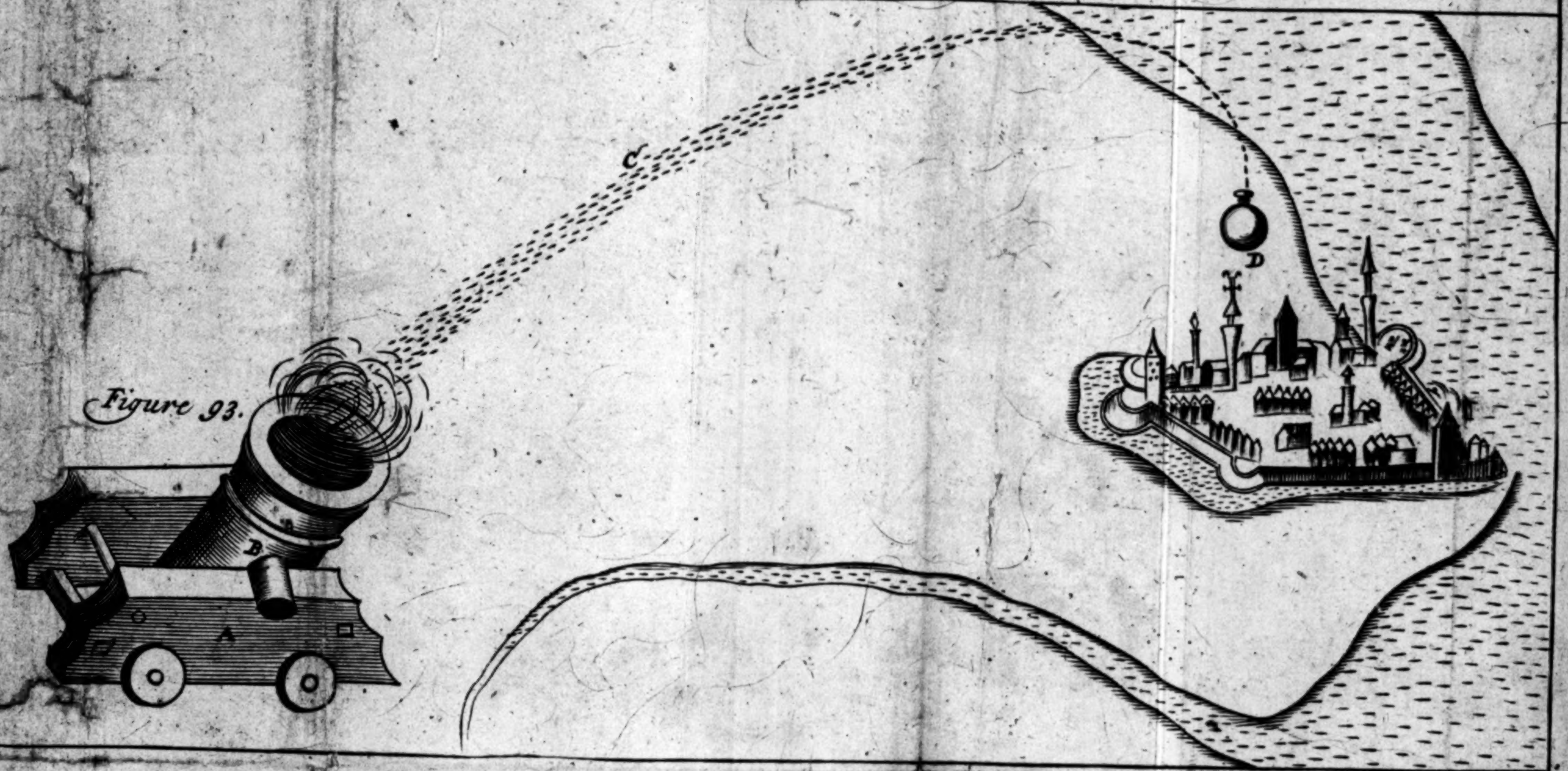


Figure 92.